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Dear Readers,

Since its onset, the COVID-19 pandemic has spread to almost all countries of the world and attack our daily routine. The coronavirus has caused unprecedented social and physical distancing measures, lockdowns of kindergartens, schools and universities, as well as businesses, and overall social life. These measures have become commonplace to curtail the spread of the disease, but they have also disrupted many regular aspects of our life, including sport and physical activity. However, scientific activities were not compromised, as most scientists were forced to spend most of their time at home, in front of their computers. Consequently, during the state of emergency and immediately after the mitigation of the pandemic measures, the MJSSM received a much larger number of quality manuscripts than ever before. So we got a much bigger than usual and very responsible job, given the significant number of high quality manuscripts submitted.

It is not the summer yet, but we have decided to introduce the second issue of this year's volume of Montenegrin Journal of Sports Science and Medicine (MJSSM). As usual it is not easy to be systematic and objective about your own product or services, so we would appreciate if you don't regret us if we bring a little more personal insight into this introductory speech, mostly due to the reason our journal continues facing the great success. Namely, the current statistics from two strongest index databases (Web of Science and Scopus) conformed this fact. So, we would like to thank the management of the journal, our editors, reviewers and authors, as well as readers, for their considerable efforts to achieve this success, and to invite all the others who have not cooperated with us so far to join in the efforts to achieve the greatest success that the journal has set out to achieve in 2021.

As we always emphasize in an introductory speech, we are sure our journal will continue working on growing academic publication in the fields of sports science and medicine; all clinical aspects of exercise, health, and sport; exercise physiology and biophysical investigation of sports performance; sport biomechanics; sports nutrition; rehabilitation, physiotherapy; sports psychology; sport pedagogy, sport history, sport philosophy, sport sociology, sport management; and all aspects of scientific support of the sports coaches from the natural, social and humanistic side, in various formats: original papers, review papers, editorials, short reports, peer review - fair review, as well as invited papers and award papers, as well as promote all other academic activities of Montenegrin Sports Academy and Faculty for Sport and Physical Education at University of Montenegro, such as publishing of academic books, conference proceedings, brochures etc.

As we usually do at the end of the introduction speech, we thank this issue authors, who have chosen precisely our Journal to publish their manuscripts, and we would like to invite you to continue our cooperation to our mutual satisfaction. Thank you all of you for reading us and we hope you will find this issue of MJSSM informative enough.

Editors-in-Chief,
Prof. Dusko Bjelica, PhD
Assoc. Prof. Stevo Popovic, PhD

ORIGINAL SCIENTIFIC PAPER

Do Pain and Function Improve after Dextrose Prolotherapy or Autologous Platelet-Rich Plasma Injection in Longstanding Groin Pain?

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ABSTRACT Longstanding groin pain is a non-infectious and inflammatory chronic condition that causes inguinal pain in athletes. We compared dextrose prolotherapy (15% dextrose solution) and platelet-rich plasma (autologous platelet gel, plasma rich in growth factors, platelet concentrate) injections in male soccer players with longstanding groin pain. Forty elite male soccer players, ages between 13 and 33, with longstanding groin pain were treated. Patients were randomly divided into the dextrose prolotherapy (n= 9) and platelet-rich plasma injection (n= 6) groups. Following three injections, all patients were enrolled in the 12-week progressive home exercise protocol. Pain and function were assessed using the visual analogue (VAS) and Nirschl Pain Phase Scale (NPPS) scores before, one month after, and six months after the injection, respectively. VAS and NPPS scores decreased in both of the dextrose prolotherapy and the platelet-rich plasma injection groups. A decrease in pain and improvement in function were evident at a month after injection, and they remained favourable at the end of six months (VAS overall, p <0.001 and p= 0.003, respectively) (NPPS overall, p <0.001 and p= 0.007, respectively). A difference between the dextrose prolotherapy and the platelet-rich plasma injection groups was not observed at both time points (VAS, p= 0.3, p= 0.7, and p= 0.6 respectively) (NPPS, p= 0.6, p= 0.9, and p= 0.9 respectively). Dextrose prolotherapy and platelet-rich plasma injections decreased pain and improved function in longstanding groin pain treatment of male soccer players. These treatments should be considered in patients who are not responding to conservative treatment modalities.

KEY WORDS longstanding groin pain, athletic pubalgia, injection, symphysis pubis, bone marrow oedema

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DEXTROSE PROLOTHERAPY FOR LONGSTANDING GROIN PAIN
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Introduction

Longstanding groin pain is a non-infectious and inflammatory chronic condition that affects symphysis pubis and surrounding tissues (Jardí et al., 2014). It is an overuse injury of the groin area in athletes participating in strenuous athletic activities, especially among soccer players (Angoules, 2015). Kicking, turning, twisting, cutting, pivoting, and sprinting activities associated with sports such as soccer, rugby, gridiron football, ice hockey, Australian rules football, and distance running have been linked to this pathology (Angoules, 2015; Jardí et al., 2014). The incidence rate of groin pain is estimated at 10% to 18% per year among male soccer players (Hölmich et al., 1999). Groin pain is often accompanied by other adductor or hip pathologies (Omar et al., 2008), such as a microtear of the adductor longus tendon attachment at the pubis, rather than an isolated entity and time to complete resolution of symptoms may extend up to 1 year (Cunningham et al., 2007). Failure to return to the prior level of sports function may be as high as 25% (Batt, McShane, & Dillingham, 1995).

Different treatments have been recommended for longstanding groin pain, ranging from conservative management to surgical procedures (Choi, McCartney, & Best, 2011; McKim, Taunto, & Kirchner, 1999; Scarpone, Rabago, Zgierska, Arbogast, & Snell, 2008; Scholten, Massimi, Dahmen, Diamond, & Wyss, 2015; Topol, Reeves, & Hassanein, 2005; Watkin, Gallegos, Moisey, & Charlton, 1995). Conservative treatment initially in-

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Conflict of interest: None declared.

cludes rest, limited activity, ice and use of anti-inflammatory medication, which is followed by a rehabilitation program (Hopp, Culemann, Kelm, Pohlemann, & Pizanis, 2013). Other suggested treatment options include steroids and local anaesthetic (Choi et al., 2011), dextrose prolotherapy (DP) (Topol et al., 2005), platelet-rich plasma (PRP) (Scholten et al., 2015) injections, anticoagulation therapy (Watkin et al., 1995), and compression shorts (McKim et al., 1999).

Dextrose prolotherapy, which consists of concentrated dextrose as an irritant, has been used in ligament or tendon insertions as a proliferant (Scarpone et al., 2008). The proliferative response to dextrose was thought to be a result of the higher osmolarity of the injected solution than that of the interstitial tissue. Evidence suggests the release of transforming growth factor beta-1, platelet-derived growth factor, connective tissue growth factor, epithelial growth factor, and basic fibroblastic growth factor were stimulated when exposed to various glucose concentrations (Murphy et al., 1999). DP has been reported to decrease pain and improve function in the treatment of musculoskeletal pain and sports-related soft tissue injuries (Scarpone et al., 2008). PRP injection is a relatively newer method than DP injection (Scholten et al., 2015). With PRP injection, high concentrations of growth factors are transmitted directly to a lesion, which in turn initiates the natural healing process (Scholten et al., 2015).

A few studies with an encouraging biological basis and theory on DP and PRP injection for groin pain have suggested the beneficial effects of these treatments (Scholten et al., 2015; Topol et al., 2005). However, applicable data are insufficient to support the routine clinical use of these therapies in this disease. To our knowledge, no previous study has compared the effects of DP and PRP injection in the treatment of groin pain. This study thus investigated whether DP and PRP injections could decrease pain and improve the function of longstanding groin pain in elite male soccer players. Our aim was to compare the effects of DP and PRP injections on pain and function at one and six months using the visual analogue scale (VAS) and the Nirschl Pain Phase Scale (NPPS), respectively.

Methods

Patients

A retrospective cohort study in patients with longstanding groin pain was designed. Data of 15 elite male soccer players with the diagnosis of longstanding groin pain who were referred to the Sports Medicine Department were analysed. The Hacettepe University Ethics Committee on Research with Human Subjects (Decision Number: GO 18/1205) approved the study. The median age of all patients was 20 years old (min: 18 years old, max: 33 years old). There was no significant difference in age between the DP and the PRP groups (p= 0.07) (Table 1).

TABLE 1. Age, Visual Analogue Scale (VAS) and Nirschl Pain Phase Scale (NPPS) scores of dextrose prolotherapy (DP) and platelet-rich plasma (PRP) groups

	DP group (n= 9)	**PRP group (n= 6)**	**P**
Age, years old, median (min-max)	19 (18 - 33)	22.5 (20 - 32)	0.07
VAS scores, median (min-max)			
Pre-injection	8 (5 - 9)	7 (5 - 9)	0.4
1st months	2 (1 – 3)	2 (1 – 6)	0.8
6th months	1 (0 – 2)	1 (0 – 6)	0.7
NPPS scores, median (min-max)			
Pre-injection	5 (3 – 7)	4.5 (3 – 6)	0.6
1st months	2 (1 – 2)	1.5 (1 – 5)	0.9
6th months	1 (0 – 1)	0.5 (0 – 5)	0.9

Note. DP - dextrose prolotherapy, min - minimum, max - maximum, NPPS - Nirschl Pain Phase Scale, PRP - platelet-rich plasma.

Patients with anterior and medial groin pain for at least six months, who resisted to non-steroidal anti-inflammatory medicine (NSAIDs), stretching, physical therapy modalities and other conservative treatment methods, were included. Groin pain was defined as pain that is exacerbated by walking, pelvic motion, adductor stretching, abdominal muscle strengthening exercises, or movement from a seated to a standing position, and may radiate into the lower abdominal muscles, perineum, inguinal region, scrotum or medial thigh. All of the participants had pain on the pubic symphysis and the pubic ramus. The diagnosis of longstanding groin pain was made by clinical examination that included tenderness on palpation of the symphyseal region, the Single Adductor, the Adductor Squeeze, and the Bilateral Adductor tests (Verrall, Slavotinek, Barnes, & Fon, 2005).

Clinical staging was based on the classification proposed by Rodriguez et al. (2001) that included clinical findings and diagnostic features. All of the patients clinical stages were Stage III (bilateral symptoms, inguinal pain involving the adductor and abdominal muscles, pain with kicking, sprinting, directional changes, etc., inability to continue sport participation) or Stage IV (inguinal pain involving the adductor and abdominal muscles, pain re-

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ferred to the pelvic girdle and lumbar spine with defecation, sneezing, and walking on uneven terrain, inability to perform activities of daily living). Longstanding groin pain diagnosis was confirmed with magnetic resonance imaging (MRI) in each soccer player, which is the standard technique for longstanding groin pain. A hyper-intense signal on T2-weighted images within the symphysis and adjacent parasymphyseal region and bilateral symphyseal subchondral bone marrow oedema extending from anterior to posterior were present in all patients' MRI.

Patients were excluded from the study if they had received local steroid injections within the previous six months or NSAIDs within the first week before their clinical application. Patients with a sports hernia, inguinal wall deficiency, iliopsoas strain, stress, and avulsion fractures, intra-articular hip joint injury or other relevant pathologies, such as snapping hip syndrome, low back pain, and nerve compression, were excluded.

Treatment procedures

Dextrose Prolotherapy Preparation and Injection

Dextrose prolotherapy was prepared by mixing 6 mL of 20% dextrose solution (Polifleks, Polifarma, Turkey) and 2 mL of prilocaine (Citanest, AstraZeneca, UK), resulting in an 8 mL 15% solution. The injection area was prepared with povidone-iodine (Isosol, Merkez, Turkey), to prevent infection. After this preparation, the dextrose solution was injected using a 22G needle (BD Microlance, Becton, Dickinson and Company, NJ, USA) into the tenderest pubic area using the peppering technique (a single skin portal and 3 or 4 penetrations to the tendon fascia), while the patient was in a supine position with a leg slightly abducted and externally rotated at the hip. Three DP injections were performed at one-week intervals. Patients were told not to exercise during the three weeks of the injection period.

PRP Preparation and Injection

Fifty millilitres (50 ml) of blood was collected from the veins in antecubital fossa into sodium citrate tubes (BD Vacutainer sodium citrate tubes, Becton, Dickinson and Company, NJ, USA). The blood was then centrifuged for eight (8) minutes at 1500 rpm using a desktop centrifuge (NF 800, Nüve, Turkey). This spin separated the whole blood into three layers: an upper layer consisting mainly of plasma and platelets, a middle layer consisting of white blood cells (known as the buffy coat), and a bottom layer consisting mainly of red blood cells (Dhurat & Sukesh, 2014). The upper layer with the buffy coat was transferred to sterile tubes, and a second centrifugation was utilized to concentrate platelets. The upper two thirds of the plasma were platelet-poor plasma, while the lower third was PRP. After extraction of the platelet-poor plasma, 5 ml of PRP was attained. This was injected using a 22G needle (BD Microlance 3, Becton, Dickinson and Company, NJ, USA) into the most tender pubic area using the peppering technique as described for DP.

Rehabilitation Program after Injection

Systemic and local complications related to injections were not observed in both groups. After the last injection, patients received the same 12-week progressive home exercise protocol including a range of motion, core stability, stretching, cardiovascular training, strengthening exercises of the pelvis, hip, abdominal and gluteal muscles by a sports physician.

Patients were told not to run during the first week after injection. From Days 7 to 14 they could jog, and from Days 14 to 28 they were able to increase distance and speed as tolerated. Forceful kicking was avoided for 28 days. Patients were not allowed to take NSAIDs or any other painkillers during this period.

Follow-up data

Data were obtained on all patients before, one month after, and six months after the first injection. Outcomes were measured through VAS scores for pain during exercise or sport, and NPPS scores of athletic overuse injuries, which has seven phases of disability based on injury severity, to determine the functional impairment level (Table 2) (O'Connor, Howard, Fieseler, & Nirschl, 1997).

TABLE 2. Nirschl Pain Phase Scale of Athletic Overuse Injuries (O'Connor et al., 1997)

Phase	Description
Phase 1	Stiffness or mild soreness after activity. Pain is usually gone within 24 hours.
Phase 2	Stiffness or mild soreness before activity that is relieved by warm-up. Symptoms are not present during activity but return afterward, lasting up to 48 hours.
Phase 3	Stiffness or mild soreness before specific sport or occupational activity. Pain is partially relieved by warm-up. It is minimally present during activity, but does not cause the athlete to alter activity.
Phase 4	Similar to phase 3 pain but more intense, causing the athlete to alter performance of the activity. Mild pain occurs with activities of daily living but does not cause a major change in them
Phase 5	Significant (moderate or greater) pain before, during, and after activity, causing alteration of activity. Pain occurs with activities of daily living but does not cause a major change in them.
Phase 6	Phase 5 pain that persists even with complete rest. Pain disrupts simple activities of daily living and prohibits doing household chores.
Phase 7	Phase 6 pain that also disrupts sleep consistently. Pain is aching in nature and intensifies with activity.

Statistical Analyses

The type of injections, PRP or DP, was the independent variable. VAS and NPPS scores were dependent variables. All statistical analyses were performed using IBM SPSS Statistics for Windows, V22.0 (IBM Corp). Variables were assessed using the visual (histograms, probability plots) and analytical methods (Kolmogorov-Smirnov/Shapiro-Wilk's test) for normal distribution. Descriptive analyses were presented using frequencies, medians, and minimum-maximum values since variables were not normally distributed. The Mann-Whitney U test was used to compare age, VAS, and NPPS scores between DP and PRP groups. Friedman tests were conducted to whether there is a significant change in the VAS and NPPS scores over time. The Wilcoxon test was performed to test the significance of pairwise differences using the Bonferroni correction to adjust for multiple comparisons; 5% type-I error level was used to infer statistical significance.

Results

Visual Analogue Scale Scores

A decrease in pain was observed in a month according to VAS within each group compared to the initial scores (Table 1). Both groups showed significant improvements in the VAS scores at all follow-ups. There were no significant differences between groups regarding VAS scores at pre-injection, 1st month and 6th month of follow-up (p= 0.3, p= 0.7, and p= 0.6 respectively) (Figure 1). In the DP group, the median VAS scores were 8 (min: 5, max: 9) at pre-injection, 2 (min: 1, max: 3) at first month and 1 (min: 0, max: 2) at sixth month, and the decrease of VAS through time points was statistically significant (overall p <0.001, from pre-injection to 1st month p= 0.007, from 1st month to 6th month p= 0.006). In the PRP group, the median VAS scores were 7 (min: 5, max: 9) at pre-injection, 2 (min: 1, max: 6) at first month and 1 (min: 0, max: 6) at sixth month, and the decrease of VAS through time points was statistically significant (overall p= 0.003, from pre-injection to 1st month p= 0.027, from 1st month to 6th month p= 0.025). The improvement was maintained from the first injection to the six-months follow-up for both groups.

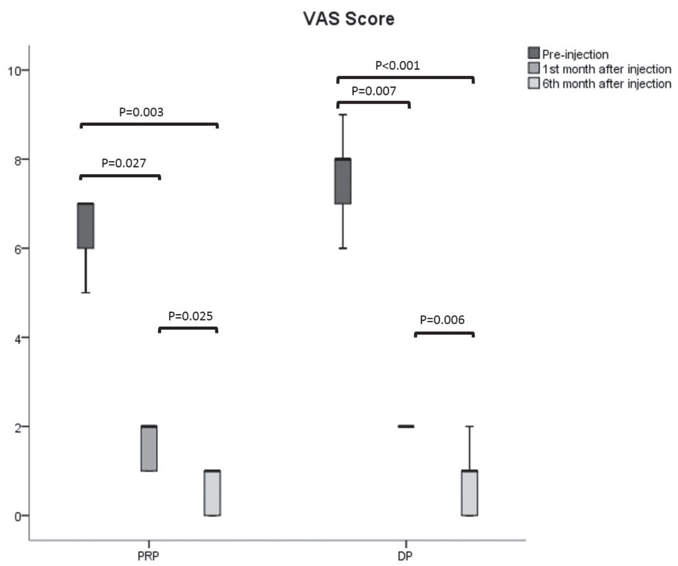

FIGURE 1. The box plots showing the initial and follow-up Visual Analogue Scale (VAS) scores of dextrose prolotherapy (DP) and platelet-rich plasma (PRP) group

Nirschl Pain Phase Scale Scores

Both groups showed significant improvements in the NPPS scores at all follow-ups. At the 1st month, functional improvements were observed according to NPPS scores within each group compared to the initial scores (Table 1). There were no significant differences between groups regarding NPPS scores at pre-injection, 1st month and 6th month of follow-up (p= 0.6, p= 0.9, and p= 0.9 respectively) (Figure 2). In the DP group, the median NPPS scores were 5 (min: 3, max: 7) at pre-injection, 2 (min: 1, max: 2) at first month and 1 (min: 0, max: 1) at sixth month, and the decrease of VAS through time points was statistically significant (overall p <0.001, from pre-injection to 1st month p= 0.007, from 1st month to 6th month p= 0.003). In the PRP group; median NPPS scores were 4.5 (min: 3, max: 6) at pre-injection, 1.5 (min: 1, max: 5) at first month and 0.5 (min: 0, max: 5) at sixth month, and the decrease of VAS through time points was statistically significant (overall p= 0.007, from pre-injection to 1st month p= 0.039, from 1st month to 6th month p= 0.025). The improvement was maintained from the first injection to 6 months' follow-up for both groups.

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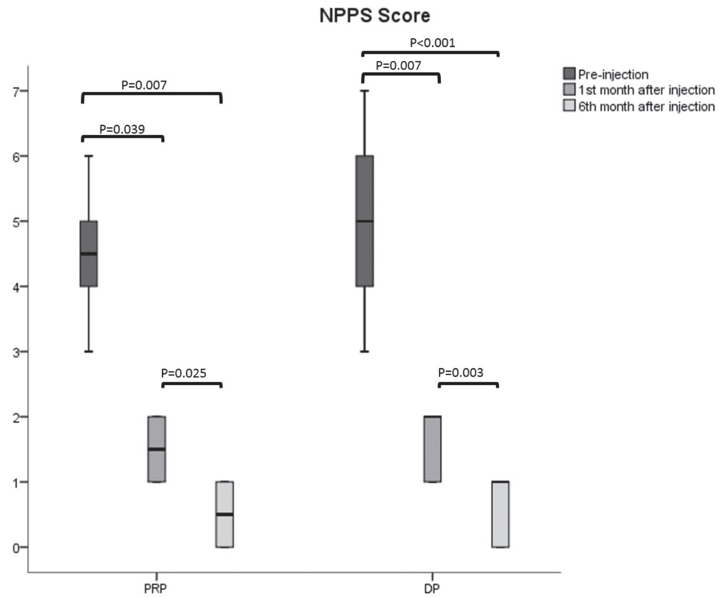

FIGURE 2. The box plots showing the initial and follow-up Nirschl Pain Phase Scale (NPPS) scores of dextrose prolotherapy (DP) and platelet-rich plasma (PRP) groups

Discussion

Pain and function changes in elite soccer players diagnosed with longstanding groin pain were assessed before and after DP and PRP injection in this study. The results of our study demonstrated the beneficial effects of both DP and PRP injection therapies on both function and pain in patients with longstanding groin pain. A few studies have proposed the favourable effects of both DP and PRP injection in groin pain (Scholten et al., 2015; Topol & Reeves, 2008). Nevertheless, to the best of our knowledge, the effectiveness of DP and PRP on decreasing pain and improving function in groin pain was not compared. We were able to compare pain and function changes before and after DP and PRP injections.

Difference between DP and PRP injection was not significant. Both VAS and NPPS scores decreased at one and six months after DP and PRP injections. Improvement in pain and function was recorded after a month of treatment, and this effect lasted up to six months.

In an animal study that investigated the mechanical effects of prolotherapy on stretch-injured ligaments, Jensen et al. (2008) found that DP increased the cross-sectional area of medial collateral ligaments compared with saline-injected and uninjured controls; however, DP injections did not alter other measured properties in their model. Apart from the animal study, DP has been used mostly in knee osteoarthritis studies. Our findings were in line with previous DP studies that reported knee pain and functional score improvement (Rabago et al., 2013; Eslamian & Amouzandeh, 2015). A study on lateral epicondylosis with DP reported a decrease in pain and improved grip strength compared to controls (Scarpone et al., 2008). Another study presented the benefit of DP on patients with painful knees, shoulders and lateral elbows (Lyftogt, 2007). A patient with chronic shoulder pain was treated at three sessions by DP, and they reported a 90% reduction of pain and complete restoration of normal activity (Seenauth, Inouye, & Langland, 2018). There was only a case series using DP for the treatment of groin pain (Topol et al., 2008). Researchers treated 75 elite athletes who were suffering from groin pain with DP injections, which consisted of monthly injections of 12.5% dextrose with 0.5% lidocaine in abdominal and adductor attachments on the pubis. Similar to our results, DP therapy yielded substantial reductions in VAS and NPPS scores (Topol et al., 2008).

VAS and NPPS scores also decreased in the PRP injected groin pain patients in our study. A decrease in pain and improvement in function was recorded in one and six months after injections. Use of PRP has recently been becoming widespread as it also delivers mediators that enhance tissue healing (Kon et al., 2011). Laboratory evidence suggests that PRP may have a positive effect on tendon healing-related processes as neo-vascularization is important for regeneration (Alsousou, Thompson, Hulley, Noble, & Willett, 2009). Clinical studies on PRP demonstrated promising results for the treatment of tendinopathies over the past few years (Gosens, Peerbooms, Van Laar, & Den Oudsten, 2011; Peerbooms, Sluimer, Bruijn, & Gosens, 2010). Our findings were in line with these studies. Tan et al. (2016) reported improvement in VAS and Mayo elbow scores of 56 patients who were suffering from refractory lateral epicondylitis after PRP injection. In 2006, Mishra et al. (2006) suggested that concentrated growth factors in PRP could be used to initiate a healing response in a damaged tendon. In their study evaluating the effect of PRP injection in patients with chronic elbow tendinosis, it was found that the PRP group had better results than the control group (Mishra & Pavelko, 2006). The beneficial effects of PRP have also been demonstrated on plantar fasciitis (Kim & Lee, 2014). Our findings for longstanding groin pain were in line with previous DP studies. Despite so many studies in different clinical tables using PRP injection, there are limited studies on PRP applied for groin pain (Scholten et al., 2015; St-Onge, MacIntyre, & Galea, 2015). In a case report, Scholten et al. (2015) used ultrasound-guided needle tenotomy and PRP injection in the treatment of a male elite lacrosse player with athletic pubalgia, and they found that improved pain and return to full pain-free plays at the previous level of intensity eight weeks after the injection. In another case report, St-Onge et al. (2015) used two PRP injections to a tear in the rectus abdominis of a male hockey player. They found that the patient returned to his prior level of performance in 3.5 weeks (St-Onge et al., 2015). Our findings related to PRP injection were consistent with previous PRP studies reporting improvement in pain and functional score.

PRP is a treatment that requires sampling and condensing thrombocytes from the patient and spending time for the centrifuge process. Furthermore, this method needs valid and reliable blood processing consumables and a centrifuge. The variable properties of platelet preparation vary slightly between companies, depending on several factors (Scholten et al., 2015). DP, in contrast, is less costly and an easier option. There are currently no published studies comparing DP and PRP treatments for longstanding groin pain, and we were not able to demonstrate a difference between the two treatment options. DP is a low-cost, less time consuming, and effective longstanding groin pain treatment method as is PRP injections.

In vivo studies showed that PRP may have an anti-inflammatory effect by inhibiting the NF-KB pathway. (Utku et al., 2017) Each millilitre of PRP solution contains 1.5-2 million platelets, which represents a 5-fold increase in platelet and growth factors (Lai et al., 2015). In contrast, DP shows its effect by increasing PDGF levels. DP has been shown to be effective in the repair of connective tissue injuries due to its irritative nature (Sit et al., 2016). Both DP and PRP, although acting in different physiological ways, are useful for OP patients who did not respond to the other therapeutic options such as physical therapy and exercise therapy.

Our study has several limitations. The retrospective design is a limitation; nevertheless, reduced pain and improved function after one and six months using DP and PRP injections is a valuable finding. The small number of patients restricted our statistical methods; however, early outcomes with both methods revealed a favourable outcome. Another limitation was the absence of a placebo-controlled group. Soccer players who did not benefit from previous medical and physical therapy methods wanted to go back to their sporting activities as soon as possible, and we were not able to establish a placebo control group. The peppering technique was used in both the DP and the PRP injections. We observed that dry needling as a part of the peppering technique had therapeutic effects as it was presented in other tendon studies (Creaney, Wallace, Curtis, & Connell, 2011; Kampa & Connell, 2010). We do attribute the positive results we have found to the effect of treatments since the same peppering technique was used in both our treatment groups. Subsequent prospective studies with the placebo group should focus on a larger sample of participants that will provide a better understanding of the DP and PRP injections on longstanding groin pain. Despite these limitations, we have proven that DP and PRP are safe, relatively simple, and potentially effective treatment methods for the treatment of longstanding groin pain.

Conclusion

We compared time-dependent pain and function changes before and after DP and PRP injections in the treatment of longstanding groin pain. Both injections improved pain and function after a month, and this improvement sustained at six months without any reported complications. Both treatments seem to be effective for longstanding groin pain and should be considered in patients who are not responding to other conservative modalities. It should not be forgotten that DP is a cost-effective and less time-consuming treatment option for longstanding groin pain. Further prospective studies in larger patient groups are needed, in which researchers may use not only clinical measures but also radiological and biological findings as secondary outcome measures.

References

Alsousou, J., Thompson, M., Hulley, P., Noble, A., & Willett, K. (2009). The biology of platelet-rich plasma and its application in trauma and orthopaedic surgery. *The Journal of Bone and Joint Surgery. British Volume*, *91-B*(8), 987–996. doi: 10.1302/0301-620x.91b8.22546

Angoules, A. G. (2015). Osteitis pubis in elite athletes: Diagnostic and therapeutic approach. *World Journal of Orthopedics*, *6*(9), 672. doi: 10.5312/wjo.v6.i9.672

Batt, M. E., McShane, J. M., & Dillingham, M. F. (1995). Osteitis pubis in collegiate football players. *Medicine and Science in Sports and Exercise*, *27(5),* 629–633. doi: 10.1249/00005768-199505000-00003

Choi, H., McCartney, M., & Best, T. M. (2011, January). Treatment of osteitis pubis and osteomyelitis of the pubic symphysis in athletes: A systematic review. *British Journal of Sports Medicine*, Vol. 45, pp. 57–64. doi: 10.1136/bjsm.2008.050989

Creaney, L., Wallace, A., Curtis, M., & Connell, D. (2011). Growth factor-based therapies provide additional benefit beyond physical therapy in resistant elbow tendinopathy: A prospective, single-blind, randomised trial of autologous blood injections versus platelet-rich plasma injections. *British Journal of Sports Medicine*, *45*(12), 966–971. doi: 10.1136/bjsm.2010.082503

Cunningham, P. M., Brennan, D., O'Connell, M., MacMahon, P., O'Neill, P., & Eustace, S. (2007). Patterns of

DOI 10.26773/mjssm.200901

Bone and Soft-Tissue Injury at the Symphysis Pubis in Soccer Players: Observations at MRI. *American Journal of Roentgenology*, *188*(3), W291–W296. doi: 10.2214/AJR.06.0051

Dhurat, R., & Sukesh, M. (2014). Principles and Methods of Preparation of Platelet-Rich Plasma: A Review and Author's Perspective. *Journal of Cutaneous and Aesthetic Surgery*, *7*(4), 189. doi: 10.4103/0974-2077.150734

Eslamian, F., & Amouzandeh, B. (2015). Therapeutic effects of prolotherapy with intra-articular dextrose injection in patients with moderate knee osteoarthritis: a single-arm study with 6 months follow up. *Therapeutic Advances in Musculoskeletal Disease*, *7*(2), 35–44. doi: 10.1177/1759720X14566618

Gosens, T., Peerbooms, J. C., Van Laar, W., & Den Oudsten, B. L. (2011). Ongoing positive effect of platelet-rich plasma versus corticosteroid injection in lateral epicondylitis: A double-blind randomized controlled trial with 2-year follow-up. *American Journal of Sports Medicine*, *39*(6), 1200–1208. doi: 10.1177/0363546510397173

Hölmich, P., Uhrskou, P., Ulnits, L., Kanstrup, I. L., Bachmann Nielsen, M., Bjerg, A. M., & Krogsgaarda, K. (1999). Effectiveness of active physical training as treatment for long-standing adductor-related groin pain in athletes: Randomised trial. *Lancet*, *353*(9151), 439–443. doi: 10.1016/S0140-6736(98)03340-6

Hopp, S. J., Culemann, U., Kelm, J., Pohlemann, T., & Pizanis, A. (2013). Osteitis pubis and adductor tendinopathy in athletes: A novel arthroscopic pubic symphysis curettage and adductor reattachment. *Archives of Orthopaedic and Trauma Surgery*, *133*(7), 1003–1009. doi: 10.1007/s00402-013-1777-7

Jardí, J., Rodas, G., Pedret, C., Til, L., Cusí, M., Malliaropoulos, N., … Maffulli, N. (2014). Osteitis pubis: can early return to elite competition be contemplated? *Translational Medicine @ UniSa*, *10*, 52–58. doi: 10.14273/unisa-446

Jensen, K. T., Rabago, D. P., Best, T. M., Patterson, J. J., & Vanderby, R. (2008). Response of knee ligaments to prolotherapy in a rat injury model. *American Journal of Sports Medicine*, *36*(7), 1347–1357. doi: 10.1177/0363546508314431

Kampa, R. J., & Connell, D. A. (2010). Treatment of tendinopathy: is there a role for autologous whole blood and platelet rich plasma injection? *International Journal of Clinical Practice*, *64*(13), 1813–1823. doi: 10.1111/j.1742-1241.2010.02432.x

Kim, E., & Lee, J. H. (2014). Autologous Platelet-Rich Plasma Versus Dextrose Prolotherapy for the Treatment of Chronic Recalcitrant Plantar Fasciitis. *PM and R*, *6*(2), 152–158. doi: 10.1016/j.pmrj.2013.07.003

Kon, E., Mandelbaum, B., Buda, R., Filardo, G., Delcogliano, M., Timoncini, A., … Marcacci, M. (2011). Platelet-Rich Plasma Intra-Articular Injection Versus Hyaluronic Acid Viscosupplementation as Treatments for Cartilage Pathology: From Early Degeneration to Osteoarthritis. *Arthroscopy: The Journal of Arthroscopic & Related Surgery*, *27*(11), 1490–1501. doi: 10.1016/J.ARTHRO.2011.05.011

Lai, L. P., Stitik, T. P., Foye, P. M., Georgy, J. S., Patibanda, V., & Chen, B. (2015). Use of Platelet-Rich Plasma in Intra-Articular Knee Injections for Osteoarthritis: A Systematic Review. *PM and R*. doi: 10.1016/j.pmrj.2015.02.003

Lyftogt, J. (2007). Subcutaneous prolotherapy treatment of refractory knee, shoulder, and lateral elbow pain. *Australasian Musculoskeletal Medicine*, *12*(2), 110–112.

McKim, K. R., Taunto, J. E., & Kirchner, G. D. (1999). The Effectiveness of a Compression Short in the Treatment of Athletes with Osteitis Pubis. *Clinical Journal of Sport Medicine*, *9*(2), 112. Abstracts from the Annual Symposium of the Ca.

Mishra, A., & Pavelko, T. (2006). Treatment of chronic elbow tendinosis with buffered platelet-rich plasma. *American Journal of Sports Medicine*, *34*(11), 1774–1778. doi: 10.1177/0363546506288850

Murphy, M., Godson, C., Cannon, S., Kato, S., Mackenzie, H. S., Martin, F., & Brady, H. R. (1999). Suppression subtractive hybridization identifies high glucose levels as a stimulus for expression of connective tissue growth factor and other genes in human mesangial cells. *The Journal of Biological Chemistry*, *274*(9), 5830–5834. doi: 10.1074/jbc.274.9.5830

O'Connor, F. G., Howard, T. M., Fieseler, C. M., & Nirschl, R. P. (1997). Managing Overuse Injuries a Systematic Approach. *Physician and Sportsmedicine*, *25*(5), 88–113. doi: 10.3810/psm.1997.05.1359

Omar, I. M., Zoga, A. C., Kavanagh, E. C., Koulouris, G., Bergin, D., Gopez, A. G., … Meyers, W. C. (2008). Athletic Pubalgia and "Sports Hernia": Optimal MR Imaging Technique and Findings. *RadioGraphics*, *28*(5), 1415–1438. doi: 10.1148/rg.285075217

Peerbooms, J. C., Sluimer, J., Bruijn, D. J., & Gosens, T. (2010). Positive Effect of an Autologous Platelet Concentrate in Lateral Epicondylitis in a Double-Blind Randomized Controlled Trial. *The American Journal of Sports Medicine*, *38*(2), 255–262. doi: 10.1177/0363546509355445

Rabago, D., Patterson, J. J., Mundt, M., Kijowski, R., Grettie, J., Segal, N. A., & Zgierska, A. (2013). Dextrose Prolotherapy for Knee Osteoarthritis: A Randomized Controlled Trial. *The Annals of Family Medicine*, *11*(3), 229–237. doi: 10.1370/afm.1504

Rodriguez, C., Miguel, A., Lima, H., & Heinrichs, K. (2001). Osteitis Pubis Syndrome in the Professional Soccer Athlete: A Case Report. *Journal of Athletic Training*, *36*(4), 437.

Scarpone, M., Rabago, D. P., Zgierska, A., Arbogast, G., & Snell, E. (2008a). The efficacy of prolotherapy for lateral epicondylosis: A pilot study. *Clinical Journal of Sport Medicine*, *18*(3), 248–254. doi: 10.1097/JSM.0b013e318170fc87

Scarpone, M., Rabago, D. P., Zgierska, A., Arbogast, G., & Snell, E. (2008b). The efficacy of prolotherapy for lateral epicondylosis: A pilot study. *Clinical Journal of Sport Medicine*, *18*(3), 248–254. doi: 10.1097/

JSM.0b013e318170fc87

Scholten, P. M., Massimi, S., Dahmen, N., Diamond, J., & Wyss, J. (2015). Successful treatment of athletic pubalgia in a lacrosse player with ultrasound-guided needle tenotomy and platelet-rich plasma injection: A case report. *PM and R*, *7*(1), 79–83. doi: 10.1016/j.pmrj.2014.08.943

Seenauth, C., Inouye, V., & Langland, J. O. (2018). Dextrose Prolotherapy for Chronic Shoulder Pain: A Case Report. *Alternative Therapies in Health and Medicine*, *24*(1), 56–60.

Sit, R. W. S., Chung, V. C. H., Reeves, K. D., Rabago, D., Chan, K. K. W., Chan, D. C. C., … Wong, S. Y. S. (2016). Hypertonic dextrose injections (prolotherapy) in the treatment of symptomatic knee osteoarthritis: A systematic review and meta-analysis. *Scientific Reports*. doi: 10.1038/srep25247

St-Onge, E., MacIntyre, I. G., & Galea, A. M. (2015). Multidisciplinary approach to non-surgical management of inguinal disruption in a professional hockey player treated with platelet-rich plasma, manual therapy and exercise: a case report. *The Journal of the Canadian Chiropractic Association*, *59*(4), 390–397.

Tan, X. xiang, Ju, H. yang, Yan, W., Jiang, H. jiang, Su, J. ping, Dong, H. jun, … Zou, D. bao. (2016). Autologous platelet lysate local injections for the treatment of refractory lateral epicondylitis. *Journal of Orthopaedic Surgery and Research*, *11*(1), 2–7. doi: 10.1186/s13018-016-0349-2

Topol, G. A., & Reeves, K. D. (2008). Regenerative injection of elite athletes with career-altering chronic groin pain who fail conservative treatment: A consecutive case series. *American Journal of Physical Medicine and Rehabilitation*, *87*(11), 890–902. doi: 10.1097/PHM.0b013e31818377b6

Topol, G. A., Reeves, K. D., & Hassanein, K. M. (2005). Efficacy of dextrose prolotherapy in elite male kicking-sport athletes with chronic groin pain. *Archives of Physical Medicine and Rehabilitation*, *86*(4), 697–702. doi: 10.1016/j.apmr.2004.10.007

Utku, B., Dönmez, G., Erişgen, G., Akin, Ş., Demirel, H. A., Korkusuz, F., & Doral, M. N. (2017). Meloxicam and diclofenac do not change VEGF and PDGF-AB serum levels of platelet-rich plasma. *Turkish Journal of Medical Sciences*. doi: 10.3906/sag-1602-60

Verrall, G. M., Slavotinek, J. P., Barnes, P. G., & Fon, G. T. (2005). Description of pain provocation tests used for the diagnosis of sports-related chronic groin pain: Relationship of tests to defined clinical (pain and tenderness) and MRI (pubic bone marrow oedema) criteria. *Scandinavian Journal of Medicine and Science in Sports*, *15*(1), 36–42. doi: 10.1111/j.1600-0838.2004.00380.x

Watkin, N. A., Gallegos, C. R., Moisey, C. U., & Charlton, C. A. C. (1995). Osteitis pubis: A case of successful treatment with anticoagulants. *Acta Orthopaedica*, *66*(6), 569–570. doi: 10.3109/17453679509002317

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Effects of a Four-Week Core Stability Exercise on Functional Movement and Balance in People with Mild Lower-limb Discomfort

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ABSTRACT This study aimed to investigate the effects of a short-term core stability exercise on functional movement and balance in people with mild lower-limb discomfort. Twenty people with mild lower-limb discomfort were randomly assigned to control (CG) and core stability exercise training groups (SG, n=10 each). The SG completed twenty 30-min training sessions consisting of Pilates exercises for four weeks. Functional movement, balance, and discomfort level were assessed before and after core stability exercise, using a functional movement test, balance test and visual analogue scale (VAS), respectively. A mixed ANOVA with repeated measures was performed to determine the differences. SG demonstrated a significant increase in hurdle step ($p = 0.024$, group × time effect) and shoulder mobility ($p = 0.037$, group × time effect). The dynamic balance scores were significantly increased from the baseline in both limbs (right, $p = 0.007$; left, $p = 0.011$, time effect). Post-hoc pairwise comparisons indicated these increases were significant only in SG. Additionally, ankle pain was significantly reduced in SG ($p = 0.023$, group × time effect). This study highlights that four weeks of core stability exercise can positively affect the lower limbs' functional movement and balance in people with mild lower-limb discomfort.

KEY WORDS core stability exercise, balance, functional movement

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Introduction

Insufficient physical activity induced by sedentary lifestyle is one of the critical risk factors in diseases such as cardiovascular diseases, cancer, and diabetes (Bauman & Owen, 1991; Shephard, 1990; Wang et al., 2019). While proper exercise can reduce the inflammatory response (Beavers et al., 2015), blood pressure (Wong et al., 2018), and the possibility of metabolic disease (Krankel et al., 2019), modern technology has led to decrease in physical activity and an increase a sedentary lifestyle (Church et al., 2011). Studies have reported that people with prolonged, unbroken periods of sitting are more likely to suffer discomforts, such as minor muscle pain, soreness, and stiffness (Søndergaard, Olesen, Søndergaard, De Zee, & Madeleine, 2010). The persistence of this condition may cause spine dysfunction, resulting in a reduction in the ability of the musculoskeletal system (Marshall & Gyi, 2010). Given that the human body is a firmly linked chain system across many joints, any misalignment in the system can damage other parts of the body (Rivera, 1994).

Core stability exercise has been widely used to improve activities of daily living and sports while keeping the spine stabilized (Barr, Griggs, & Cadby, 2007). The core muscles supporting the lumbar-pelvic-hip complex include transverse abdominis, diaphragm, pelvic floor muscles, and deep fibres of the lumbar multifidus. The stabilization of these muscle groups supports the control of trunk motion in all three planes and, therefore, contributes to body stabilization as well as force and power generation in the movement

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(Kibler, Press, & Sciascia, 2006). The movement in the core stability exercise has its origin in the Pilates exercise programme, which emphasizes inter-segmental coordination of bodily movement. As such, the realignment of the body is promoted in core stability exercise based on the fine and continuous nature of the movement control (Herrington & Davies, 2005). Furthermore, it has been demonstrated that the effectiveness of core stability exercise in chronic low back pain is facilitated by strengthening the deep spinal muscles (Hodges, 2003).

The previous literature indicated that the core stability exercise had been implemented mainly to characterize the performance enhancement of athletes (Bagherian, Ghasempoor, Rahnama, & Wikstrom, 2019) and the improvement of balance and functional movement for the elderly people who fall (Granacher, Gollhofer, Hortobagyi, Kressig, & Muehlbauer, 2013). However, there are a limited number of studies assessing the effect of core stability exercise in healthy adults, rather than in athletes or older populations. Moreover, the intervention period of core stability exercise was relatively long, as was the duration of the training session. These long training schedules may hinder the efficiency of the exercise programme, in particular, not only for those who experience pain or irritation but also for the individuals who are too busy to exercise regularly. A general exercise programme designed for the healthy population might have a negative influence on this population; therefore, special care should be given if people suffer from minor discomfort at the muscular or joint level.

The core stability and its relation to the functional movement have been assessed with a functional movement screen (FMS), which evaluates multi-joint movements related to the core muscle in seven categories (Cook, Burton, Hoogenboom, & Voight, 2014a). The measurement process focuses on the quantitative and qualitative evaluation of mobility, stability, asymmetry and limitation of the movement. While the test tool has been adopted in many sports for injury prevention and rehabilitation, its limited scoring system might not be sensitive enough to discover the small differences in the effect of the exercise programme. Recently, for the precise assessment of physical balance, studies have attempted to incorporate advanced assessment tools such as balance boards. These measurement systems provide a precise assessment of static as well as dynamic balance control, which may add valuable information in distinguishing the group- or programme-related differences. However, the applicability of the balance board system in examining the relationship between core stability exercise and balance has not been tested yet. Moreover, whether or not the balance board system is sensitive enough to detect the changes in balance that may exist after the core stability exercise intervention for the people with discomfort in the lower extremity remains unclear.

To the best of our knowledge, there have not been any studies using the balance board system and Y-BT in people with discomfort in the lower-limb body. This study aimed to determine the effect of short-term core stability exercise on functional movement and balance in people with mild lower-limb discomfort. It was hypothesized that four weeks of core stability exercise would result in an improvement of functional body movement and balance and could reduce the perceived level of discomfort.

Methods

Participants

Twenty volunteers who experience minor lower-limb discomfort were recruited from the Texas A&M University-San Antonio (TAMUSA) community. Participants were randomly assigned into two groups: control group (CG; n=10) and stability exercise group (SG; n=10) performing a core stability exercise programme. The physical characteristics of the participants are shown in Table 1. Individuals who have been deemed not healthy enough to participate in the study by answering yes to any of the questions on the Physical Activity Readiness Questionnaire (PAR-Q) were excluded. The aim of the study, procedure, benefits, and possible risk factors were explained to the participants. A written consent form approved by the Institutional Review Board was obtained from each participant (IRB #2017-82).

TABLE 1. The Physical Characteristics of the Participants

Variables	CG(n=10)	SG(n=10)
Age (yr)	25.50±5.70	32.3±9.9
Height (cm)	170.47±11.23	161.9±9.4
Weight (kg)	77.72±15.62	75.7±20.3
Body fat (%)	25.27±8.95	25.1±12.6

Note. Values are mean±SD; BMI: body mass index; CG: control group; SG: stability exercise group.

Core Stability Exercise Programme

The core stability exercise applied in this study was based on the official programme of the Pilates Academy International-Pilates and Balanced Body University-Pilates methods. The sessions were divided into the following three stages: 1) rolling motion as a general warm-up, 2) core body and limb exercise consisting of eight movements, and 3) stretching exercise as a cool down. A video clip containing the exercise pro-

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gramme was uploaded on YouTube so that participants could easily follow the exercise movements at home by themselves (https://www.youtube.com/watch?v=uDjxxJvCd4o). While CG was asked to maintain their usual lifestyle, SG was required to perform core stability exercise twice a day, three times per week for four weeks until completing a total of twenty sessions. The researchers asked participants to check-in at least once a week for the exercise training at school. Participants were required to bring their training logs. The data from the participants who were not able to complete less than 90% of the total expected training were excluded from the data analysis in this study.

Measurements

Anthropometric Measurements

Bodyweight and height were measured using a scale and a wall stadiometer (Novel Products, USA). Body fat percentage was measured with a Biometric device (BX2000, IntelaMetrix, Inc., USA) estimating total body fat from the ultrasound measurements of three standardized body sites of the thigh, abdomen, and chest for male, or thigh, suprailiac, and triceps for female, as described by Jackson and Pollock (Jackson & Pollock, 1978; Jackson, Pollock, & Ward, 1980).

Functional Movement Screen (FMS)

Functional movements were assessed through seven movements (deep squat, hurdle step, in-line lunge, shoulder mobility, active straight leg raise, trunk stability push-up, and rotary stability) using an FMS test kit (Professional FMS Test Kit, FMS Inc., USA). Detailed instruction and scoring procedures are addressed in the previous study (Cook et al., 2014a, 2014b). Two experienced independent raters evaluated each movement pattern for three trials, and the highest score was used to evaluate the lateral symmetry of the movement further.

Balance

The balance was tested by using a YBT kit (Y-balance Test Kit, FMS Inc., USA), which examined the maximum lower extremity reach of the free leg in the anterior, posteromedial, and posterolateral directions

TABLE 2. Effects of a Four-week Core Stability Exercise on FMS

Variables (score)	Group	Before	After	Source	*F*	*p*
Deep squat	CG	2.5±0.5	2.6±0.5	Group	0.375	0.555
				Time	5.063	0.051
	SG	2.4±0.5	2.9±0.3	G×T	3.273	0.104
Hurdle step	CG	2.1±0.3	2.0±0.5	Group	1.000	0.343
				Time	2.250	0.168
	SG	2.0±0.5	2.5±0.5*	G×T	7.364	0.024
In-line lunge	CG	2.4±0.8	2.6±0.7	Group	0.031	0.864
				Time	3.645	0.089
	SG	2.2±0.9	2.7±0.5	G×T	1.000	0.343
Shoulder mobility	CG	2.3±0.5	2.0±0.7	Group	0.153	0.705
				Time	1.000	0.343
	SG	2.0±0.8	2.1±0.7	G×T	6.000	0.037
Active straight	CG	1.9±0.9	2.1±0.9	Group	0.375	0.555
				Time	6.000	0.037
	SG	1.9±0.9	2.5±0.5	G×T	1.000	0.343
Trunk stability	CG	1.8±0.9	2.6±0.7*	Group	0.698	0.425
				Time	7.500	0.023
	SG	2.4±1.1	2.6±0.7	G×T	5.063	0.051
Rotary stability	CG	1.9±0.3	2.0±0.5	Group	0.083	0.780
				Time	5.000	0.052
	SG	1.7±0.7	2.1±0.3	G×T	0.802	0.394
Total	CG	14.9±2.8	15.9±2.8	Group	0.217	0.653
				Time	7.754	0.021
	SG	14.6±3.9	17.4±1.9*	G×T	3.050	0.115

Note. Value are mean±SD; CG: control group; SG: stability exercise group; G×T: group-by-time interaction; *Significant difference compared with before ($p<0.05$).

while participants maintain a unilateral stance with the opposite leg centred on a platform. Three trials were performed for each direction. The participant's lower-limb reach was normalized to leg length. Composite reach distance is calculated using the formula: the sum of the three reach directions divided by three times the lower-limb length, multiplied by 100 (Park, 2016).

The HUMAC Balance System (HUMAC Balance, CSMi, USA) was used to measure the movement characteristics. This test compares participant's scores with normative data of their age (Girardi, Konrad, Amin, & Hughes, 2001). It provides visuals and numerical data of the path they travelled while attempting to maintain balance on different surfaces. The stability score is calculated as follows: "(S standard - A max)/S standard", where "A max" is the axis of maximum sway inches as determined at the 95% confidence interval. Participants performed for static balance tests and two dynamic balance tests, respectively. For static balance measurements, participants were instructed to maintain their balance for 30 seconds in each of four conditions: 1) with their eyes open while focusing on a red dot on the wall in 1.5 m distance at eye height while standing on a firm surface (EOFS); 2) with their eyes closed on a firm surface (ECFS); 3) with their eyes open on a soft surface (EOSS); 4) with their eyes closed on a soft surface (ECSS). For the dynamic balance measurements, participants performed five sets of squat exercises for 15 seconds in two different types of surfaces (firm; SF and soft; SS) at 45 bpm.

Muscle Strength

Isometric knee extensor and flexor strength were measured with a hand-held dynamometer (Model 01165, Lafayette, USA). Participants are seated on a chair with the knee flexed to 90 degrees. The peak force in Newton (N) was measured during knee flexion and extension. Two trials were performed for both sides of limbs in two directions with a 60 seconds rest interval between the trials. Whole-body strength was measured with a back body dynamometer (NexGen Ergonomics, USA).

TABLE 3. Effects of a Four-week Core Stability Exercise on Balance Control

	Variables (score)	Group	Before	After	Source	*F*	*p*
Y-balance	Right	CG	83.1±10.9	84.8±12.5	Group	0.145	0.712
					Time	11.870	0.007
		SG	79.0±8.5	85.1±7.0*	G×T	2.065	0.185
	Left	CG	83.1±9.7	84.1±11.4	Group	0.202	0.663
					Time	10.216	0.011
		SG	78.4±7.7	84.7±6.1*	G×T	2.611	0.141
Balance board – static	Eye Open Firm Surface	CG	91.8±2.4	91.9±2.3	Group	0.364	0.561
					Time	0.096	0.764
		SG	90.8±3.0	91.3±4.3	G×T	0.109	0.749
	Eye Close Firm Surface	CG	91.8±2.3	90.4±3.6*	Group	0.441	0.523
					Time	5.062	0.051
		SG	92.3±2.3	91.3±3.1	G×T	0.101	0.758
	Eye Open Soft Surface	CG	86.7±3.3	83.8±3.4*	Group	0.227	0.645
					Time	14.548	0.004
		SG	85.5±4.3	83.0±5.8	G×T	0.039	0.847
	Eye Close Soft Surface	CG	77.5±6.2	75.8±5.3	Group	0.340	0.574
					Time	0.163	0.696
		SG	73.4±9.7	76.2±7.6	G×T	6.544	0.031
Balance board - dynamic	Squat Firm Surface	CG	67.9±7.9	63.7±10.8	Group	3.584	0.091
					Time	1.077	0.326
		SG	51.7±25.2	62.9±10.0	G×T	4.572	0.061
	Squat Soft Surface	CG	62.1±12.7	58.8±7.7	Group	2.921	0.122
					Time	0.932	0.360
		SG	46.0±19.8	55.6±13.7	G×T	7.353	0.024

Note. Value are mean±SD; CG: control group; SG: stability exercise group; G×T: group-by-time interaction; *Significant difference compared with before ($p<0.05$).

Discomfort

We assessed the degree of discomfort using the Visual Analogue Scale (VAS). The degree of discomfort in each body site was expressed as a number between 1 and 10 cm.

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Statistical analysis

All outcome variables were averaged across the trials repeated within each assessment condition. A mixed ANOVA with repeated measures was performed to determine the between (CG and SG) and within (pre- and post-intervention) group differences. In the case of violations of the sphericity assumption, F-values were adjusted with the Greenhouse-Geisser procedure. Significant interaction effects were further analysed using pairwise comparisons (t-tests). All tests were conducted at α =0.05 and performed using SPSS 19.0 (IBM, Armonk, NY, USA).

Results

Functional Movement Screen

Descriptive statistics of the effects of the four-week core stability exercise on FMS are presented in Table 2. A significant group-by-time interaction was observed in hurdle step and shoulder mobility ($p<.05$). Post-hoc analysis indicated that while SG did improve the score of hurdle step after a four-week core stability exercise intervention, the shoulder mobility score did not change significantly in SG. There was a significant main effect of time on active straight, trunk stability, and total FMS score ($p<.05$). Only SG showed a significant increase in the total FMS score ($p<.05$).

Balance

The effects of core stability exercise on balance measures are presented in Table 3. There was no significant group-by-time interaction for any of the variables in the Y-balance test. However, a significant main effect of time on both right ($p<.01$) and left ($p<.05$) limb, post-hoc pairwise comparisons indicated a significant increase in the balance of both limbs only in SG ($p<.05$).

The results of static and dynamic balance measured with the balance board showed significant interaction effect between group and time in both static (ECSS) and dynamic (SS) balance performed on the soft surface ($p<.05$). There was a significant main effect of time in EOSS ($p<.01$), and a comparison between pre- and post-intervention indicated a significant decrease in stability score in CG ($p<.05$), whereas SG exhibited a similar static balance control.

Muscle Strength

Lower-limb and whole-body muscle strength did not change significantly for both groups (Table 4). While a significant main effect of time on right leg flexion was detected, post hoc comparisons failed to show the difference between pre- and post-intervention for both groups.

TABLE 4. Effects of a Four-week Core Stability Exercise on Strength

Variables (kg)	Group	Before	After	Source	*F*	*p*
Right Leg Extension (RLE)	CG	40.7±12.6	38.1±12.3	Group	0.039	0.848
				Time	1.907	0.201
	SG	32.5±15.5	36.4±16.7	G×T	0.003	0.955
Right Leg Flexion (RLF)	CG	25.2±8.0	27.1±8.4	Group	0.935	0.359
				Time	11.317	0.008
	SG	25.4±4.8	26.6±10.6	G×T	0.005	0.946
Left Leg Extension (LLE)	CG	33.4±9.3	35.9±6.2	Group	0.746	0.410
				Time	0.081	0.782
	SG	34.2±12.9	36.5±14.7	G×T	2.774	0.130
Left Leg Flexion (LLF)	CG	24.7±5.8	28.1±5.9	Group	0.002	0.963
				Time	1.120	0.317
	SG	22.9±5.0	26.1±8.8	G×T	0.033	0.861
Whole body muscle strength	CG	255.8±91.8	258.0±92.6	Group	1.358	0.274
				Time	4.646	0.059
	SG	191.9±81.2	235.8±82.6	G×T	2.403	0.156

Note. Value are mean±SD; CG: control group; SG: stability exercise group; G×T: group-by-time interaction.

Discomfort

Table 5 showed the exercise-induced change in VAS. There was a significant interaction between group and time in ankle pain ($p<.05$), and the VAS score of ankle pain was significantly reduced in the SG. A significant main effect of time was shown in knee pain, but no significant time-related changes for both groups were detected by post hoc comparisons.

TABLE 5. Effects of a 4-week Core Stability Exercise on VAS

Variables (cm)	Group	Before	After	Source	*F*	*p*
Body pain	CG	1.3±1.5	0.9±0.9	Group	0.277	0.611
				Time	3.608	0.090
	SG	1.9±1.8	1.2±1.8	G×T	0.123	0.734
Exercise pain	CG	2.2±1.9	1.6±1.5	Group	0.000	0.988
				Time	2.709	0.134
	SG	2.1±2.2	1.7±1.9	G×T	0.026	0.876
Waist pain	CG	2.1±1.4	2.2±1.4	Group	1.428	0.263
				Time	0.509	0.494
	SG	1.4±1.7	1.0±1.7	G×T	1.09	0.324
Knee pain	CG	2.0±1.7	1.0±1.2	Group	0.000	0.996
				Time	5.791	0.039
	SG	1.6±1.8	1.4±2.1	G×T	2.098	0.181
Pelvis pain	CG	1.9±2.1	2.3±2.2	Group	2.161	0.176
				Time	0.003	0.957
	SG	1.0±1.9	0.6±0.9	G×T	1.935	0.198
Ankle pain	CG	1.1±0.9	1.0±1.3	Group	0.355	0.566
				Time	4.683	0.059
	SG	2.1±2.2	0.5±0.9	G×T	7.488	0.023

Note. Value are mean±SD; CG: control group; SG: stability exercise group; G×T: group-by-time interaction.

Discussion

The objectives of this study were twofold: (1) to determine the effect of core stability exercise on functional body movements and balance in people with discomfort in their lower limbs, and (2) to assess whether a balance board system can be used in conjunction with Y-balance test in evaluating balance control. Our first hypothesis was partially supported by measures of FMS, balance, and VAS. Our second hypothesis was supported by the increased balance control in both static and dynamic balance conditions and confirmed the validity of using the balance board system in assessing the effects of core stability exercise on balance control.

The hurdle step, shoulder mobility, and FMS total score were significantly increased in SG after the exercise intervention. The successful completion of the hurdle step test without compromising body balance proves that movement functions were improved in a four-week intervention period. It is also likely that the observed increases in shoulder joint mobility are associated with enhanced upper limb function, such as a relaxation of the muscle through the stretching motions in the exercise programme. While the effectiveness of core stability exercise has been addressed across a wide range of groups even including the highly active collegiate athlete (Lasey & Donne, 2019), these current findings further suggest its applicability to the group experiencing discomfort in their lower limbs. However, it seems premature to generalize the significance of reduced intervention period and duration employed in this study to other contexts.

Balance control ability exhibited a significant improvement after exercise intervention. The YBT outcome indicated that the dynamic balance and functional symmetry were improved so that it reduces their risk of injury. The existing literature indicates that the YBT can evaluate the coordination of the lower-limb body and the dynamic equilibrium ability. Previous studies have used the YBT not only for the healthy adults and adolescents but also for athletes with a sprain or chronic instability in their lower limbs. The measurement reliability of Y-balance was reported to be about 0.82 to 0.87; it seems likely that it is sufficient to produce reliable results. However, we also understand that the Y-balance test may not be an ideal test for the participant with minor lower-limb discomfort. While the convenience and reliability of YBT have been demonstrated sufficiently, the measure of static balance provides additional information on the balance control. As expected, the intended use of the balance board system in this study further revealed an improvement in static balance control, which is considered to be controlled independently from the dynamic balance (Rose et al., 2002). However, interestingly, the improvement of both static and dynamic balance in SG exhibited in more challenging conditions, rather than the firm surface. Presumably, the participants' level of discomfort in this study might not be severe enough to interfere with the maintaining of equilibrium while in a stationary position. We did not conduct the reliability and construct validity to test the balance board in this study. Even though the reliability and concurrent validity of the HUMAC Balance System have been tested and verified as moderate to good in previous studies, they can be still considered to be limitations to this the study.

Furthermore, in addition to the study reporting the positive effects of yoga exercise on COP characteristics

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(Jeter, Moonaz, Bittner, & Dagnelie, 2015), the equivalent results shown in this study emphasized the importance of assessing the static balance in people with dysfunctions in musculoskeletal, somatosensory, and vestibular functions. Given that the traditional COP measure was conducted with a ground-mounted force platform in biomechanical settings and has been used as a surrogate marker for postural stability in standing balance (Piirtola & Era, 2006), the necessity of using a balance measurement system in exercise intervention protocol becomes greater.

Enhancement of core muscle strength is known to play an essential role in facilitating the dynamic stability of muscles across the segments (Panjabi, 1992). In particular, multifidus and transversus abdominis contract simultaneously to provide dynamic stability to the core muscles, leading to improved posture alignment and functional movement (Vleeming, Schuenke, Danneels, & Willard, 2014). However, the evaluation of muscle strength did not reach the statistical significance in SG, which suggests that improved functional movement and balance may occur without a substantial increase in muscle strength. A previous study reported that FMS scores of collegiate football players were positively correlated with hopping performance, but were not correlated with hip and knee strength (Willigenburg & Hewett, 2017). Lastly, although people with mild discomfort in their lower body do not usually require hospital treatment, there might be a need for more organized and specialized exercise programmes with proper intensity and duration for the purpose of injury prevention.

It is essential to mention that SG' VAS for pain was reduced significantly after the exercise intervention. Although the VAS is somewhat subjective and influenced by other contextual factors, it may reflect participants' psychological influence by being more active with the exercise programme. It has been reported that Pilates exercise improved young females' spine and shoulder pain, as well as body instability (Kim, 2017).

In summary, this study has demonstrated that four weeks of core stability exercise was beneficial for reducing the pain and discomfort by increasing the functional movement and balance. Although the sample size was small and may have limited detecting impacts on parameters, there were few studies of exercise programmes for the people with lower-limb discomfort and with a short period of training. Therefore, the authors believe that this study can serve as a positive starting point for making exercise guidelines for those populations. However, further controlled studies with a varied combination of exercise period and frequency are needed to more fully understand the effect of core stability exercise on the quality of life in people with mild pain and discomfort.

References

Bagherian, S., Ghasempoor, K., Rahnama, N., & Wikstrom, E. A. (2019). The Effect of Core Stability Training on Functional Movement Patterns in College Athletes. *Journal of Sport Rehabilitation*, 28(5), 444-449. doi: 10.1123/jsr.2017-0107

Barr, K. P., Griggs, M., & Cadby, T. (2007). Lumbar stabilization: a review of core concepts and current literature, part 2. *American Journal of Physical Medicine & Rehabilitation*, 86(1), 72-80. doi: 10.1097/01.phm.0000250566.44629.a0

Bauman, A., & Owen, N. (1991). Habitual physical activity and cardiovascular risk factors. *Medical Journal of Australia*, 154(1), 22-28. doi: 10.5694/j.1326-5377.1991.tb112841.x

Beavers, K. M., Beavers, D. P., Newman, J. J., Anderson, A. M., Loeser, R. F., Jr., Nicklas, B. J., . . . Messier, S. P. (2015). Effects of total and regional fat loss on plasma CRP and IL-6 in overweight and obese, older adults with knee osteoarthritis. *Osteoarthritis Cartilage*, 23(2), 249-256. doi:10.1016/j.joca.2014.11.005

Church, T. S., Thomas, D. M., Tudor-Locke, C., Katzmarzyk, P. T., Earnest, C. P., Rodarte, R. Q., . . . Bouchard, C. (2011). Trends over 5 decades in US occupation-related physical activity and their associations with obesity. *PloS one*, 6(5), e19657. doi:10.1371/journal.pone.0019657

Cook, G., Burton, L., Hoogenboom, B. J., & Voight, M. (2014a). Functional movement screening: the use of fundamental movements as an assessment of function-part 1. *International journal of sports physical therapy*, 9(3), 396-409.

Cook, G., Burton, L., Hoogenboom, B. J., & Voight, M. (2014b). Functional movement screening: the use of fundamental movements as an assessment of function-part 2. *International journal of sports physical therapy*, 9(4), 549-563.

DeJong, A. F., Mangum, L. C., & Hertel, J. (2020). Ultrasound Imaging of the Gluteal Muscles during the Y-Balance Test in Individuals With or Without Chronic Ankle Instability. *Journal of Athletic Training*, 55(1), 49-5. doi: 10.4085/1062-6050-363-18

Girardi, M., Konrad, H. R., Amin, M., & Hughes, L. F. (2001). Predicting fall risks in an elderly population: computer dynamic posturography versus electronystagmography test results. *The Laryngoscope*, 111(9), 1528-1532. doi:10.1097/00005537-200109000-00008

Granacher, U., Gollhofer, A., Hortobagyi, T., Kressig, R. W., & Muehlbauer, T. (2013). The importance of trunk muscle strength for balance, functional performance, and fall prevention in seniors: a systematic review. *Sports medicine*, 43(7), 627-641. doi: 10.1007/s40279-013-0041-1

Herrington, L., & Davies, R. (2005). The influence of Pilates training on the ability to contract the transversus abdominis muscle in asymptomatic individuals. *Journal of bodywork and movement therapies*, 9(1), 52-57. doi:10.1016/j.jbmt.2003.12.005

Hodges, P. W. (2003). Core stability exercise in chronic low back pain. *Orthopedic Clinics*, 34(2), 245-254. doi: 10.1016/S0030-5898(03)00003-8

Jackson, A. S., & Pollock, M. L. (1978). Generalized equations for predicting body density of men. *British journal of nutrition*, 40(3), 497-504. doi: 10.1079/BJN19780152

Jackson, A. S., Pollock, M. L., & Ward, A. (1980). Generalized equations for predicting body density of women. *Medicine and science in sports and exercise*, 12(3), 175-181.

Jeter, P. E., Moonaz, S. H., Bittner, A. K., & Dagnelie, G. (2015). Ashtanga-based yoga therapy increases the sensory contribution to postural stability in visually-impaired persons at risk for falls as measured by the wii balance board: a pilot randomized controlled trial. *PloS one*, 10(6), e0129646. doi: 10.1371/journal.pone.0129646

Kibler WB, Press J, & Sciascia A. (2006). The role of core stability in athletic function. *Sports Medicine,* 36(3) 189-198. doi: 10.2165/00007256-200636030-00001.

Kim, H. (2017). *The effect of Pilates springboard exercise on isokinetic muscular strength, functional movement in college-aged women*. Unpublished Doctoral Dissertation, Seoul, Republic of Korea: Dongduk women's University.

Krankel, N., Bahls, M., Van Craenenbroeck, E. M., Adams, V., Serratosa, L., Solberg, E. E., . . . Kemps, H. (2019). Exercise training to reduce cardiovascular risk in patients with metabolic syndrome and type 2 diabetes mellitus: How does it work? *European Journal of Preventive Cardiology*, 26(7), 701-708. doi:10.1177/2047487318805158

Lacey, M., & Donne, B. (2019). Does Fatigue Impact Static and Dynamic Balance Variables in Athletes with a Previous Ankle Injury? International Journal of Exercise Science, 12(3), 1121.

Marshall, S., & Gyi, D. (2010). Evidence of health risks from occupational sitting: where do we stand? *American journal of preventive medicine*, 39(4), 389-391. doi: 10.1016/j.amepre.2010.07.001

Plisky, P. J., Gorman, P. P., Butler, R. J., Kiesel, K. B., Underwood, F. B., & Elkins, B. (2009). The reliability of an instrumented device for measuring components of the star excursion balance test. *North American journal of sports physical therapy*, 4(2), 92.

Panjabi, M. M. (1992). The stabilizing system of the spine. Part I. Function, dysfunction, adaptation, and enhancement. *Journal of spinal disorders*, 5, 383-383. doi: 10.1097/00002517-199212000-00001

Park, W. Y. (2016). Effects of Complex Neoromuscular Training on Lower Extremity Injury Risk in Freestyle Ski Players. *The Korean Society of Living Environmental System*, 23(2), 235-242. doi: 10.21086/ksles.2016.04.23.2.235

Piirtola, M., & Era, P. (2006). Force platform measurements as predictors of falls among older people–a review. *Gerontology*, 52(1), 1-16. doi: 10.1159/000089820

Rivera, J. E. (1994). Open versus closed kinetic chain rehabilitation of the lower extremity: a functional and biomechanical analysis. *Journal of Sport Rehabilitation*, 3(2), 154-167. doi: 10.1123/jsr.3.2.154

Rose, J., Wolff, D. R., Jones, V. K., Bloch, D. A., Oehlert, J. W., & Gamble, J. G. (2002). Postural balance in children with cerebral palsy. *Developmental medicine and child neurology*, 44(1), 58-63. doi: 10.1017/S0012162201001669

Shephard, R. J. (1990). Physical activity and cancer. *International Journal of Sports Medicine*, 11(6), 413-420. doi:10.1055/s-2007-1024830

Søndergaard, K. H., Olesen, C. G., Søndergaard, E. K., De Zee, M., & Madeleine, P. (2010). The variability and complexity of sitting postural control are associated with discomfort. *Journal of Biomechanics*, 43(10), 1997-2001. doi: 10.1016/j.jbiomech.2010.03.009

Vleeming, A., Schuenke, M., Danneels, L., & Willard, F. (2014). The functional coupling of the deep abdominal and paraspinal muscles: the effects of simulated paraspinal muscle contraction on force transfer to the middle and posterior layer of the thoracolumbar fascia. *Journal of anatomy*, 225(4), 447-462. doi: 10.1111/joa.12227

Wang, Y., Lee, D. C., Brellenthin, A. G., Eijsvogels, T. M. H., Sui, X., Church, T. S., . . . Blair, S. N. (2019). Leisure-Time Running Reduces the Risk of Incident Type 2 Diabetes. *The American Journal of Medicine*. doi:10.1016/j.amjmed.2019.04.035

Willigenburg, N., & Hewett, T. E. (2017). Performance on the Functional Movement Screen™ is related to hop performance, but not to hip and knee strength in collegiate football players. *Clinical journal of sport medicine*, 27(2), 119. doi: 10.1097/JSM.0000000000000317

Wong, A., Kwak, Y. S., Scott, S. D., Pekas, E. J., Son, W. M., Kim, J. S., & Park, S. Y. (2018). The effects of swimming training on arterial function, muscular strength, and cardiorespiratory capacity in postmenopausal women with stage 2 hypertension. *Menopause*, 26(6), 653-658. doi:10.1097/GME.0000000000001288

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ORIGINAL SCIENTIFIC PAPER

Comparison of Electromyographic Amplitudes of the Adductor Magnus Muscle among Three Different Clinical Testing Positions

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ABSTRACT Although normalizing the EMG signals is necessary for physiological interpretation and comparison between muscles and between subjects, no EMG study has investigated the standardized position to achieve maximal contraction for the adductor magnus muscle. Accordingly, it is necessary to employ a maximum voluntary isometric contraction (MVIC) position that elicits the highest activation to increase the validity of EMG studies and provide accurate comparisons between studies. Therefore, the purpose of this study was to compare the peak electromyography (EMG) of the most commonly used positions in the literature (i.e., the fully extended hip and knee, hip-flexed 45°, and knee at 90°) to a novel position: prone hip extension with 90° knee flexion. An ultrasound imaging system was used to guide the surface EMG electrode placement on the adductor magnus (AM) muscle, for a group of ninety-four recreational runners. AM demonstrated the greatest MVIC activity in both prone and hip-flexed 45° positions with no significant differences between them ($p < 0.05$). However, significant differences were displayed between the AM activities while performing the fully extended hip position and the other two positions. Based on these results, it is recommended that the prone and hip-flexed 45° positions can be used to measure the MVIC of the AM interchangeably. Furthermore, the prone position can be considered to be a position of the greatest MVIC of AM, particularly when the position of hip-flexed 45° is limited as well as it can be used to quantify MVIC for both AM and hip extensor muscles simultaneously.

KEY WORDS MVIC, Adductor magnus, EMG, positions

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Introduction

The adductor magnus (AM) muscle is the largest member of the hip adductor group in terms of muscle mass. Among the hip muscles, the hip adductor group contributes 22.5% of the total muscle mass of the lower extremity (Ito, 1996). Moreover, it takes up 27% of the mass of the thigh musculature (Takizawa, Suzuki, Ito, Fujimiya, & Uchiyama, 2014). Although the AM is considered to have the second-largest physiological cross-sectional area (PSCA) among the lower limb muscles, it has the capacity to generate extension force equal to the force produced by the gluteus maximus (Ito, Moriyama, Inokuchi, & Goto, 2003). Similarly, the PCSAs of the adductor muscles are larger than the PCSA of the gluteus medius muscle (Williams, Wilson, Daynes, Peckham, & Payne, 2008). Although they account for a significant proportion of the muscle mass of the lower limb of the adductor, the contribution of the adductor muscles during gait still unclear.

Electromyography (EMG) is a good means of obtaining better insight into the functional performance of the AM muscle during multiple hip movements. However, normalizing the EMG signals is necessary to overcome the natural variability and to optimize the physiological interpretation and comparison between muscles and between subjects (Lehman & McGill, 1999). Maximal isometric voluntary contraction (MVIC) is the most broadly used approach for normalizing EMG signals, which was suggested by the SENIAM and Kinesiology's

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guidelines (Hermens, Freriks, Disselhorst-Klug, & Rau, 2000). EMG amplitudes, in this method, are expressed as a percentage of the maximum neural activation of the desired muscle (Burden, Trew, & Baltzopoulos, 2003; De Luca, 1997). This strategy is considered a powerful approach to the physiological interpretation of signals in a healthy population. However, it is essential to note that, the MVIC normalization method is influenced by the magnitude of the MVIC test and as such shows slightly lower repeatability (Ha, Cynn, Kwon, Park, & Kim, 2013). Accordingly, it is vital to choose an MVIC position that elicits the highest activation to increase the validity of EMG studies, and provide accurate comparisons between studies (Contreras, Vigotsky, Schoenfeld, Beardsley, & Cronin, 2015).

Although the degree of myoelectric activity produced by AM depends on the hip joint angle, there have been only a small number of studies investigating adductor EMG patterns in musculoskeletal conditions (Benn, Pizzari, Rath, Tucker, & Semciw, 2018; Ko, Jeon, Kim, & Park, 2019; Lovell, Blanch, & Barnes, 2012). Various MVIC positions have been used in the literature to assess the AM activity, including the position "Hips 0", "Hips 45", and "Hips 90" flexion (Benn et al., 2018; Lovell et al., 2012). Anecdotally, the AM is more effective hip extensor than either the hamstrings or gluteus maximus (Takizawa et al., 2014); however, no study has investigated the maximum activity of AM from prone hip extension position compared to the commonly used positions. Therefore, the purpose of this investigation was to compare the maximum activity of AM muscle from prone hip extension position with the broadly used positions in literature. It is hypothesized that hip extension position would elicit the highest AM MVIC activity.

Methods

Sample Characteristics

A total of 94 healthy recreational runners participated in this study (age: 32.02 ± 7.15 years, height: 176.08 ± 7.05 cm, mass 71.36 ± 8.88 kg, BMI: 22.95 ± 1.81 kg/m2). Runners were eligible to participate in the current study if they were between 20 to 40 years old (This age range was carefully chosen to represent the young, athletic population for whom the outcomes of the study are most likely to be implemented). In addition, participants have to be free from any neuromuscular, cardiopulmonary, musculoskeletal injury, particularly in the groin region, for a minimum of one year before joining the present study. The study was also limited to participants with a body mass index (BMI) below 25. Before testing, a decision was taken to exclude any data collected from participants with subcutaneous fat thickness more than 2 cm over the inner thigh as this could negatively affect the quality of EMG signals. Participants who did not meet the aforementioned criteria were excluded from the study. All participants gave their written informed consent statement in accordance with the declaration of the University of Salford Research, Innovation, and Academic Engagement Ethical Approval Panel.

Measuring Devices

There is no clear guideline for surface EMG electrode placement for AM. Moreover, the individual hip adductor muscles are close to each other at the upper medial aspect of the thigh (Watanabe, Katayama, Ishida, & Akima, 2009). Additionally, AM is a deep muscle that occasionally appears at the superficial layers of the thigh. Therefore, electrode placement over this muscle using traditional approaches such as visual or palpation methods can be difficult. Furthermore, small errors in electrode placement could increase the possibility of cross-talk, defined as picking up signals from an adjacent muscle rather than the muscle over which the electrode is placed. Therefore, a MyLab70 (Esaote, USA) ultrasound imaging system was used to locate the AM and to place the surface EMG electrode accurately.

To precisely locate AM in its most superficial position and to standardize the ultrasound probe-positioning between participants, the following protocol was followed. Initially, the distance from the greater trochanter of the femur to the lateral knee joint line was measured, and 60% of this distance was used as a guide to identify the muscle position (Figure 1). Then, an ultrasound probe (LA923) of 10 cm length was used to map out the boundaries of the posterior border of the gracilis, AM and anterior border of the medial hamstring muscle following the procedure described by Watanabe et al. (2009). This process involves putting a water-soluble transmission gel over the participant's skin and then using a probe to image the underlying muscle structures. The position of the EMG electrode was then marked using a water-based (non-toxic) marker pen on the skin in the middle of the muscle belly (i.e., between the posterior border of gracilis and anterior border of the medial hamstring) and along the length of the muscle. Finally, a disposable adhesive Ag/AgCl EMG electrode shaped in a figure-of-eight, and measuring 2.2 × 4 cm, with 1 cm in diameter conductive circles and 2 cm separating each electrode was placed over the marked area after proper skin preparation.

Testing positions

Following the electrode placement process, A DTS sensors (model 542) were attached to the surface electrode with EMG lead (542AP). This set was finally connected to a Direct Transmission System of 16 channels (Noraxon USA Inc., model 586 Tele Myo DTS Desk Receiver). EMG data were sampled at 3000 Hz, and software (Model 131 MyoResearch-XP) was used to collect the EMG amplitudes. Two adductor testing positions described by Lovell et al. (2012) were performed in the current study. It is proposed that these two positions attain the highest EMG amplitudes for the adductor muscles. An additional testing prone hip extension position was added to test the role of AM as a strong hip extensor. Each tested position is illustrated in Table 1.

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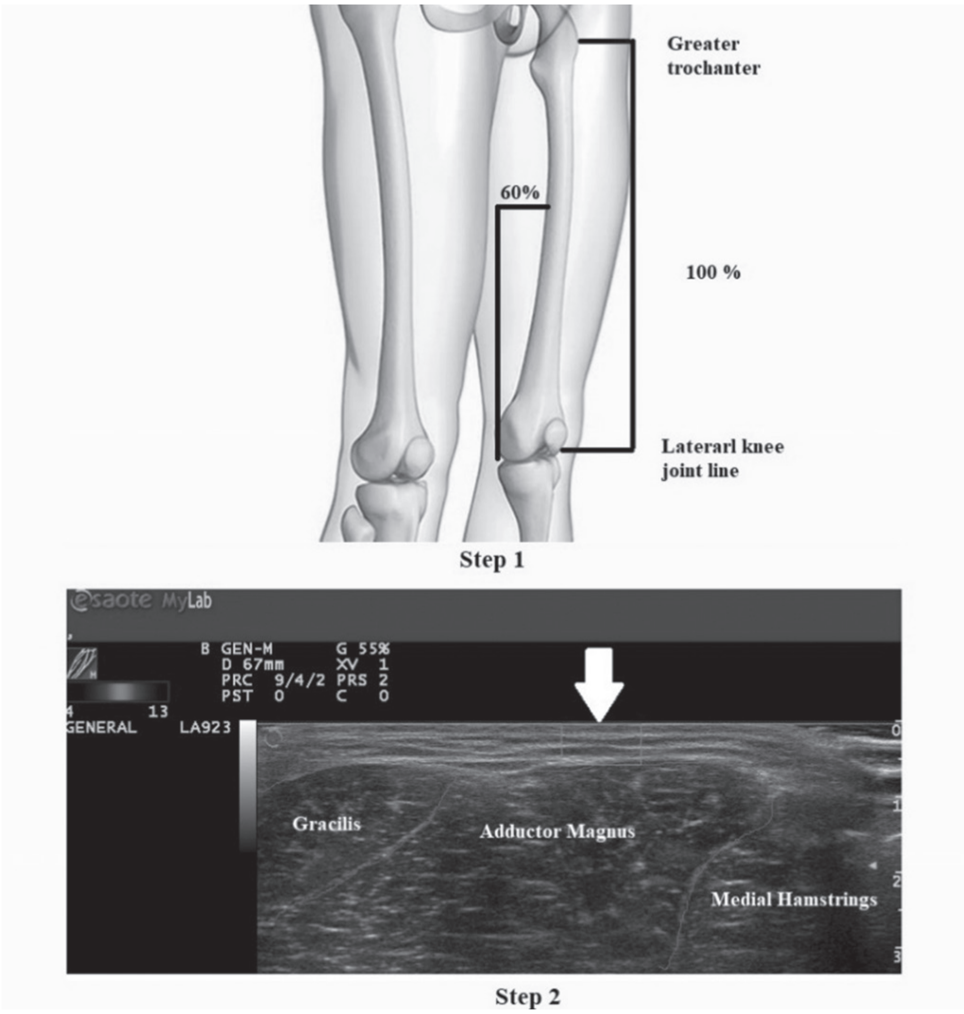

FIGURE 1. The process of adductor magnus (AM) location. Firstly, 60% of the femur length was used as a starting point to look for the AM using a probe of ultrasound on the medial aspect of the thigh (Step 1). Then, a clear definition of all muscle boundaries around AM (Step2). This followed by placing the EMG electrode centrally on the participant's skin (white arrow).

In each testing position, the participants were asked to perform three MVIC of the tested muscle for three seconds. They also were instructed to push as hard as they could in each testing position against the manual resistance with consistent verbal encouragement throughout the whole testing process. A minimum of a minute was given as rest period between each muscle contraction to eliminate the effect of fatigue.

TABLE 1. Description of testing positions

Tested positions	Description and manual resistance given by the investigator
Position 1	The participant laid down on his back with fully extended hip and knee; then he was asked to adduct both his legs maximally against manual resistance.
Position 2	The participant assumed laying position while his hip at 45° and his knee at 90°. Similar to Position 1, the participant was instructed to adduct his both thighs against manual resistance maximally.
Position 3	The participant was asked to lay on his stomach with 90° knee flexion; then he was instructed to lift his leg toward the ceiling against manual resistance.

Data processing

The data were exported as a C3D to MATLAB for processing with custom-written software in MATLAB. There were three steps to process the raw EMG data. The first step used a high-pass filter (20Hz) to remove movement artefacts and noise, as the typical frequency range of cable motion artefacts is between 1 and 50 Hz (Clancy, Morin, & Merletti, 2002). The second step was rectification and envelope detection, which made all signals positive. The final step was a low-pass filter (6Hz), which was used by (Hubley-Kozey, Deluzio, Landry, McNutt, & Stanish, 2006; Hubley-Kozey, Hatfield, Wilson, & Dunbar, 2010; Winter & Yack, 1987) to create a linear envelope, as recommended for EMG processing for dynamic tasks (Hermie J Hermens et al., 1999). Using a filter of 6Hz maintained at least 95% of signal power (Shiavi, Frigo, & Pedotti, 1998). Following

EMG processing, the data were exported to a Microsoft Excel 2016 spreadsheet to obtain a final result. The average RMS EMG signal was calculated separately from the middle one second of each of the three MVICs. The largest of the three values for each testing position was chosen for the tested muscle for each participant. Then, the peak value of the three tested position was used to normalize the peak EMG recordings from the other testing positions.

Statistical analysis. One-way repeated-measure ANOVAs were performed after checking normality using the Kolmogorov-Smirnov test in the statistical analysis was carried out with the Statistical Package for the Social Sciences (SPSS) (IBM SPSS Statistics 25). Post hoc comparisons were performed with the Bonferroni test. The level of statistical significance was set at $P < 0.05$.

Results

Table 2 displays the normalized peak EMG for the different testing positions for the AM muscle. The AM demonstrated greatest MVIC amplitude in Positions 2 and 3, which were significantly greater than in Position 1 ($p \leq 0.001$). In addition, there was no significant difference in AM MVIC between positions 2 and 3 ($p = 1.000$) (Figure 2).

TABLE 2. The mean ±SD of normalized peak EMG amplitudes of adductor magnus during each test position

	Position 1	Position 2	Position 3	P value
Adductor magnus	0.57 ± 0.24	0.85 ±0.22	0.82 ± 0.21	p≤0.001*

Note. SD - standard deviation; * - Significant, $p < 0.05$.

Discussion

The purpose of this study was to compare MVIC obtained from AM at different testing positions in healthy subjects. To date, there are no complete datasets that have reported the best position associated with the highest MVIC of AM muscle. Therefore, this is the first study to report on this potential link considering the different action of the AM. The primary finding of this investigation was that a position of prone with knee flexion demonstrated MVIC activation values nearly equal to that produced by the traditional position used (hip at 45°) with no significant difference between them. However, the Hip 0° position presented the lowest MVIC activation values. The results from the current study are partially consistent with Lovell et al. (2012) who found that EMG activation was highest when the hip at 45° position for AM, but no direct comparison can be made because of the different positions performed (prone position not included). Moreover, it has been reported by Ko et al. (2019) that no significant difference between the activation of the AM and GMax and hamstring muscles during prone position. Possible mechanisms that explain this result are discussed below.

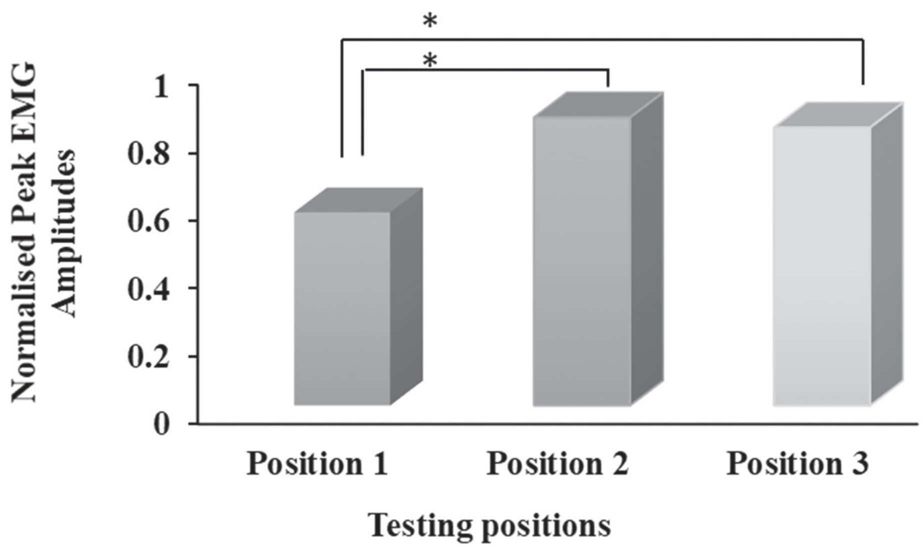

FIGURE 2. Comparison of normalized peak EMG amplitudes of adductor magnus during fully extended hip and knee (Position 1), hip-flexed 45° and knee at 90° (Position 2), and prone hip extension with 90° knee flexion (Position 3) positions.

The AM is dissected into four parts based on courses of the corresponding perforating arteries from the deep femoral artery. Each portion of the AM may have its distinct role depending on its dynamic circumstances. The AM is divided into a hamstrings part and adductor part. The hamstrings part attaches to the adductor tubercle at the distal end of the femur (designed for stabilizing the hip joint), while the adductor part corresponds to the remaining three portions attached to the linea aspera of the femur (function as displacers for moving the thigh through an extensive range of motion) (Takizawa et al., 2014). The mass distribution and

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dissection of AM into four anatomical parts which refers as a hamstring part and adductor part suggested a various role in hip adduction during gait, and this is supported by the EMG signals in the various testing positions. It does seem plausible that the AM, due to its hip extension role, would be more active in the prone position as it may be contributing to the hip extension.

Interestingly, in the current study, no significant difference exists between the MVIC activation of the AM at prone (position 3) and when the hip at 45° (position 2). This may be due to the recording site of EMG signals, which was placed over the hamstrings part of AM (located with the guidance of ultrasonography). The results of the present study could, therefore, be used to obtain the MVIC of AM from prone (position 3) when the position of hip at 45° is limited, for example, during the early stage of adductor-related groin injuries. Therefore, Position 3 can be used interchangeability with Position 2 and can be used as a position to produce MVIC for both AM and Gluteus maximum (GMax) muscle.

The results of the current study showed that the MVIC values for the extended position for hip and knee joints (Position 1) significantly lower than that of the more flexed position of hip at 45° (Position 2) and the prone position. However, the moment arm length of the AM at flexed hip position is greater than that at extended position (Németh & Ohlsén, 1985). Recent research found that the posterior fibres of the AM muscle (where EMG electrode is placed) have the greatest moment arm for hip extension relative to other hip muscles in the extended hip position (Ko et al., 2019). Moreover, regardless of hip position, the posterior fibres of the adductor magnus are powerful extensors of the hip, similar to the hamstring muscles (Neumann, 2010). The current study is limited to a specific cohort (fit, lean runners). This choice was made in order to decrease the subcutaneous fat layer to its minimum level, thus, decreasing the effect of the fat layer on EMG signals to a minimal level. Further studies are needed to explore the position that produces the highest MVIC EMG activity of AM in females. However, a previous study suggested gender differences presented in the fat percentage of lower limb (Yamauchi, Kurihara, Yoshikawa, Taguchi, & Hashimoto, 2015). Another limitation of this study that of measuring the activity of the superficial fibres of AM using surface EMG. Fine wire EMG is recommended to measure the EMG activity of the deep layers of AM. However, the application of fine-wire EMG is technically difficult and not widely used in clinical settings (Takizawa et al., 2014).

Conclusion

Specific to male runners, the prone and supine position with hip-flexed at 45° can be used to measure the MVIC of the AM interchangeably. The results of the current study suggest that clinicians could consider the prone position as a position of greatest MVIC of AM, particularly while rehabilitating the groin-related injuries. In addition, the prone position can be used to quantify MVIC for both AM and GMax muscles in the same testing position. Future research could use different populations, such as athletic females, and also test deeper layers of AM.

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References

Benn, M. L., Pizzari, T., Rath, L., Tucker, K., & Semciw, A. I. (2018). Adductor magnus: An EMG investigation into proximal and distal portions and direction specific action. *Clinical Anatomy*, 31(4), 535-543.

Burden, A., Trew, M., & Baltzopoulos, V. (2003). Normalisation of gait EMGs: a re-examination. *Journal of Electromyography and Kinesiology*, 13(6), 519-532.

Clancy, E. A., Morin, E. L., & Merletti, R. (2002). Sampling, noise-reduction and amplitude estimation issues in surface electromyography. *Journal of Electromyography and Kinesiology*, 12(1), 1-16. doi:10.1016/S1050-6411(01)00033-5

Contreras, B., Vigotsky, A. D., Schoenfeld, B. J., Beardsley, C., & Cronin, J. (2015). A comparison of two gluteus maximus EMG maximum voluntary isometric contraction positions. *PeerJ*, 3, e1261.

De Luca, C. J. (1997). The use of surface electromyography in biomechanics. *Journal of applied biomechanics*, 13(2), 135-163.

Ha, S.-m., Cynn, H.-s., Kwon, O.-y., Park, K.-n., & Kim, G.-m. (2013). A reliability of electromyographic normalization methods for the infraspinatus muscle in healthy subjects. *Journal of human kinetics*, 36(1), 69-76.

Hermens, H. J., Freriks, B., Disselhorst-Klug, C., & Rau, G. (2000). Development of recommendations for SEMG sensors and sensor placement procedures. *Journal of Electromyography and Kinesiology*, 10(5), 361-374. doi:10.1016/s1050-6411(00)00027-4

Hermens, H. J., Freriks, B., Merletti, R., Stegeman, D., Blok, J., Rau, G., . . . Hägg, G. (1999). European recommendations for surface electromyography. *Roessingh research and development*, 8(2), 13-54.

Hubley-Kozey, C. L., Deluzio, K. J., Landry, S. C., McNutt, J. S., & Stanish, W. D. (2006). Neuromuscular alterations during walking in persons with moderate knee osteoarthritis. *Journal of Electromyography and Kinesiology*, 16(4), 365-378. doi:10.1016/j.jelekin.2005.07.014

Hubley-Kozey, C. L., Hatfield, G. L., Wilson, J. L. A., & Dunbar, M. J. (2010). Alterations in neuromuscular patterns between pre and one-year post-total knee arthroplasty. *Clinical Biomechanics*, 25(10), 995-1002.

doi:10.1016/j.clinbiomech.2010.07.008

Ito, J. (1996). Morphological analysis of the human lower extremity based on the relative muscle weight. *Okajimas folia anatomica Japonica*, 73(5), 247.

Ito, J., Moriyama, H., Inokuchi, S., & Goto, N. (2003). Human lower limb muscles: an evaluation of weight and fiber size. *Okajimas Folia Anatomica Japonica*, 80(2-3), 47-55.

Ko, H.-i., Jeon, S.-y., Kim, S.-h., & Park, K.-n. (2019). Comparison of hip extensor muscle activity including the adductor magnus during three prone hip extension exercises. *Physiotherapy theory and practice*, 35(5), 451-457.

Lehman, G. J., & McGill, S. M. (1999). The importance of normalization in the interpretation of surface electromyography: A proof of principle. *Journal of Manipulative and Physiological Therapeutics*, 22(7), 444-446. doi:10.1016/S0161-4754(99)70032-1

Lovell, G. A., Blanch, P. D., & Barnes, C. J. (2012). EMG of the hip adductor muscles in six clinical examination tests. *Physical Therapy in Sport*, 13(3), 134-140. doi:10.1016/j.ptsp.2011.08.004

Németh, G., & Ohlsén, H. (1985). In vivo moment arm lengths for hip extensor muscles at different angles of hip flexion. *Journal of Biomechanics*, 18(2), 129-140.

Neumann, D. (2010). *Kinesiology of the musculoskeletal system: foundations for rehabilitation*. St. Louis, MO: Mosby Elsevier.

Shiavi, R., Frigo, C., & Pedotti, A. (1998). Electromyographic signals during gait: criteria for envelope filtering and number of strides. *Medical and Biological Engineering and Computing*, 36(2), 171. doi:10.1007/BF02510739

Takizawa, M., Suzuki, D., Ito, H., Fujimiya, M., & Uchiyama, E. (2014). Why adductor magnus muscle is large: The function based on muscle morphology in cadavers. *Scandinavian Journal of Medicine & Science in Sports*, 24(1), 197-203. doi:10.1111/j.1600-0838.2012.01466.x

Watanabe, K., Katayama, K., Ishida, K., & Akima, H. (2009). Electromyographic analysis of hip adductor muscles during incremental fatiguing pedaling exercise. *European Journal of Applied Physiology*, 106(6), 815-825. doi:10.1007/s00421-009-1086-6

Williams, S. B., Wilson, A. M., Daynes, J., Peckham, K., & Payne, R. C. (2008). Functional anatomy and muscle moment arms of the thoracic limb of an elite sprinting athlete: the racing greyhound (Canis familiaris). *Journal of Anatomy*, 213(4), 373-382. doi:10.1111/j.1469-7580.2008.00962.x

Winter, D. A., & Yack, H. J. (1987). EMG profiles during normal human walking: stride-to-stride and inter-subject variability. *Electroencephalography and Clinical Neurophysiology*, 67(5), 402-411.

Yamauchi, J., Kurihara, T., Yoshikawa, M., Taguchi, S., & Hashimoto, T. (2015). Specific characterization of regional storage fat in upper and lower limbs of young healthy adults. *Springerplus*, 4(1), 402.

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ORIGINAL SCIENTIFIC PAPER

The Influence of the Relative Age Effect in the Czech Youth Ice Hockey League

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ABSTRACT The issue of Relative Age Effect (RAE) focuses on the causes and consequences of the failure to respect development patterns of individuals in relation to their success, especially in sports. This study aims to determine whether the influence of the RAE can be proven in the Czech youth ice hockey league (U15) (n=744). A Chi-Square test ($\chi 2$) has shown that the influence in the whole investigated group cannot be rejected ($\chi 2$=25.34, p<0.01, w=0.11). The RAE can be rejected in the group of players (n=78) from the three best teams of the competition ($\chi 2$=3.09, p=0.38, w=0.11); the influence of the RAE can also be rejected in players (n=75) from the three worst teams ($\chi 2$=0.53, p=0.91, w=0.05). The assessment of RAE on playing positions has shown that the RAE can be rejected ($\chi 2$=7.31, p=0.06, w=0.22) in the most productive forwards (n=50) as well as in the least productive forwards (n=50) ($\chi 2$=0.48, p=0.92, w=0.06). The RAE is rejected in the group of the most productive defensemen (n=50) ($\chi 2$=1.71, p=0.11, w=0.11), and in the group of the least productive defensemen (n=50) ($\chi 2$=4.15, p=0.25, w=0.17). The RAE cannot be rejected ($\chi 2$=8.88, p=0.03, w=0.35) in the group of best goaltenders (n=24); the RAE is rejected in the group of the worst goaltenders (n=24) ($\chi 2$=1.5, p=0.68, w=0.14). Although the results have proven that the RAE cannot be rejected in the entire research group, there is no evidence of its influence (with the exception of the best goaltenders) in individual playing positions.

KEY WORDS birth date, ice hockey, talent, productivity, chronological age

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Introduction

The issue of Relative Age Effect (RAE), also referred to as Birth Date Effect (Karcher, Ahmaidi, & Buchheit, 2014) or Birth Quarter (Larouche, Laurencelle, Grondin, & Trudeau, 2010), is the deviation of birth date distribution of selected groups of athletes from the normal frequency distribution in the general population. The results of many studies from the field of sports show that, in particular, athletes in the youth categories born in the first months of the calendar year are often more successful, than those born in the second half of the year. However, it is impossible that more talented athletes would be born during a particular part of the year rather than in another (Lames, Augste, Dreckmann, Görsdorf, & Schimanski, 2008).

The greater success of chronologically older players is based on the fact that individuals born for instance in January may have a nearly 12-month developmental lead (in terms of physiological, morphological and psychological assumptions), compared to the individuals born in December of the same year (Agricola, Zháněl, & Hubáček, 2013; Arrieta, Torres-Unda, Gil, & Irazusta, 2015; Musch & Grondin, 2001). Athletes born earlier have notably higher levels of strength, endurance, and speed, which enables them to achieve better performance, especially in sports with high demands on their fitness levels. Consequently, these athletes are often identified as above average in selections for fitness-intensive sports. Another reason is the mechanism called the 'vicious circle' (Arrieta et al., 2015; Helsen, Winckel, & Williams, 2005). Older individuals with an above-average performance are often referred to as talented; therefore, they receive more significant support from their coaches, parents, and friends; this increases their motivation to work harder and to devote more time to the selected sport (Arrieta et al., 2015; Hollings, Hume, & Hopkins, 2012). However, as the age in-

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creases, the developmental differences equalize, the influence of the RAE weakens (Bjerke¸ Pedersen, Aune, & Lorås, 2017; Ford & Wiliams, 2011; Lames et al., 2008) and the players previously referred to as 'talented' often become only average players. Moreover, many chronologically younger players at this age have already ended their careers (due to burnout syndrome) because of insufficient support to fully develop their potential (Abbot & Collins, 2004; Arrieta et al., 2015; Peréz & Pain, 2008). However, the full potential of an athlete (in terms of his/her biological age) may manifest itself up to the age of 21 (Lames, Augste, Dreckmann, Görsdorf, & Schimanski, 2009). Based on the above, it is clear that the main reason for the emergence of influence of the RAE is the disregard of the different levels of ontogenetic development (biological age) of the athletes as well as the disregard of the significant differences between the athletes born at the beginning, and at the end of the year (calendar, respectively chronological age). In apparently the first study dealing with the influence of the RAE in sports (Grondin, Deshaies, & Nault, 1984), the authors indicated for the first time the higher representation of chronologically older hockey players and volleyball players. Barnsley, Thompson, and Barnsley (1985) examined hockey players from junior leagues (18–20 years) and from the NHL. The results showed that four times more players among the juniors were born in the first quarter of the year than in the rest of the year. The number was only slightly lower among the NHL players. Grondin (in Musch & Grondin, 2001) states that in the 1980s, 40% of the players playing in the NHL were born in the first quarter, 30% in the second, 20% in the third and only 10% in the last quarter. The significant influence of the RAE in NHL players was explained by Barnley and Thompson (1988) and later by Fumarco, Gibbs, Jarvis, and Rossi (2017) by the fact that the talent selection during the pubescence is significantly affected by the different levels of the biological development of hockey players. Sherar, Baxter-Jones, Faulkner, and Russell (2007) focused on 14–15-year-old hockey players from the Canadian province of Saskatchewan. Because the emphasis was on the body height and overall 'maturity' of hockey players when choosing players for this category, the influence of the RAE could be expected: this was confirmed by the results when the birth frequency curve in individual months had a declining character from January to December. The influence of the RAE in ice hockey has been demonstrated in studies published since 2010 by several authors, for instance, Addona and Yates (2010), Deaner, Lowen, and Cobley (2012), Gibbs, Jarvis, and Dufur (2012), Hancock, Adler, and Côte (2013), Nolan and Howell (2010), Parent-Harvey and Desjardins (2014).

There is currently no known study comparing the influence of the RAE in players of the best and worst teams in a long-term national competition; the researches mostly focus on short-term tournaments of national teams. There is also no known assessment of the influence of the RAE on the long-term productivity for particular player positions in a national competition. Therefore, the first aim of this study was to assess the influence of the RAE in the group of Czech ice hockey players playing in the category of the U15 youth league. The following aim was to determine if the influence of the RAE is stronger in players from the best teams of the competition than in players from the worst teams. We also wanted to learn about the RAE in relation to the success of players in individual positions – defensemen and forwards based on points at the end of the season, and goaltenders based on the number of saves in relation to their time spent on the ice.

Methods

Participants

The research group consisted of Czech male ice hockey players born in the years 2001–2002 (n=744) playing in the 2016/2017 season of the Czech U15 youth league (ELMD). A total of 30 teams from all over the Czech Republic participated in the competition. The influence of the RAE on the position of the team in the table was assessed based on the birth date of hockey players from the three best teams that had taken part in the final tournament for the title of league champions (n=78) and hockey players from the three worst teams in the table that had finished last in their groups and eventually descended from the league (n=75). When assessing the influence of the RAE in forwards and defensemen, the date of birth of the 50 most productive and the 50 least productive forwards and defensemen, according to the points at the end of the season, were used. To assess the quality of goaltenders, the number of minutes spent on ice in relation to the percentage success of their saves was chosen as the main criterion. During the RAE assessment, the goaltenders were divided by the quartile range into the worst and best quarters. The research group consisted of the 24 best goaltenders and the 24 worst goaltenders of the league. The research data (birth dates) were obtained from the publicly available youth ice hockey website mladeznicky hokej.cz (https://www.hokej.cz/mladez/rozcestnik-souteze).

Procedure

The inclusion of ice hockey players into individual quarters of the year was performed according to their birth as follows (Qi=quarter): Q1 (January–March), Q2 (April–June), Q3 (July–September), Q4 (October–December). The analysis of the research data was carried out following the formulation of research questions according to these research criteria: (1) assessment of the influence of the RAE in the entire research group; (2) assessment of the influence of the RAE in the hockey players of the three best and the three worst teams; (3) assessment of the influence of the RAE in the most productive and least productive forwards; (4) assessment of the influence of the RAE in the most productive and least productive defensemen; (5) assessment of the influence of the RAE in the best and worst goaltenders.

Statistical analysis

To assess the conformity of theoretical (expected) frequency distribution and empirical (observed) frequency

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distribution, the Chi-Square test (χ2) in the Goodness of Fit variant was used due to the large group size; data were analysed using the online calculator available on the link: https://www.socscistatistics.com/tests/goodnessoffit/Default2.aspx.

To assess the effect size for relations between categorical variables (RAE), Cohen's w calculation, was used, which enables to measure the effect size (ES, Cohen, 1988) as small (w=0.10), medium (w=0.30) or large (w=0.50). The theoretical frequency distribution was based on official published data obtained from the data.un.org database. It was based on the data on the number of children born in the year, which was the average value of the birth year of the monitored players. The theoretical data distributions for individual research groups and individual quarters are presented in Table 1. The research data were processed using the STATISTICA 10 software and Microsoft Office - Excel.

TABLE 1. Theoretical (Expected) Frequency of Hockey Players' Birth Date (%)

Year of birth	Q_1	Q_2	Q_3	Q_4
2001	24.50%	26.50%	25.80%	23.20%
2002	24.60%	26.30%	25.80%	23.40%

Note. Q_i = quarter of the year.

Results

The Influence of the RAE in all hockey players

The most hockey players were born in Q1 (n=226) and least in Q4 (n=128). The absolute frequencies of the number of hockey players born in individual quarters (226; 214; 176; 128) have a decreasing tendency, which suggests a possible influence of the RAE in the entire research group. The assessment of the statistical significance of the influence of the RAE using the Chi-Square test (Table 2) showed a statistically significant difference in the distribution of birth data. It can be stated that influence of the RAE in the entire research group of hockey players cannot be rejected, even though the assessment of effect size (ES) showed only a small effect (w=0.11).

TABLE 2. The Influence of the RAE in the Entire Research Group of Hockey Players

Values	Q_1	Q_2	Q_3	Q_4	n	χ^2	p	w
Absolute	226	214	176	128	744			
Relative	30.40%	28.80%	23.70%	17.20%	100%	25.34	0.00	0.11
Δ	43.0	18.3	-16.0	-46.1	R=89.1			

Note. χ^2=Chi-Square test; p=significance level; w=effect size; Δ=delta (absolute observed minus absolute expected values); R=variation range (Δmax – Δmin).

RAE in hockey players from 3 best and 3 worst teams

After converting monthly frequencies of hockey players from the three best and three worst teams into individual quarters, the highest frequency was found in Q1 (n=23) and the lowest in Q4 (n=12) in the players of three best teams (n=78). The highest frequency was found in Q2 (n=21) and the lowest in Q1 (n=16) in the players of three worst teams (n=75), which does not support the assumption of the presence of influence of the RAE. Statistical analysis (Table 3) did not show statistically significant differences in the distribution of birth data in any of the examined groups. We reject the influence of the RAE in both research groups of hockey players; the differences between the theoretical and empirical distributions of frequencies are both statistically (p=0.38 and 0.91) and materially (ES, w=0.11, and w=0.05) insignificant.

TABLE 3. Comparison of Influence of the RAE in Hockey Players from the 3 Best and the 3 Worst Teams of the Competition

Teams	Values	Q_1	Q_2	Q_3	Q_4	n	χ^2	p	w
3 best teams	Absolute	23	21	22	12	78	3.09	0.38	0.11
	Relative	29.50%	26.60%	28.20%	15.40%	100%			
	Δ	3.8	0.5	1.9	-6.3	R=10.1			
3 worst teams	Absolute	16	21	19	19	75	0.53	0.91	0.05
	Relative	21.30%	28.00%	25.30%	25.30%	100%			
	Δ	-2.5	1.3	-0.4	1.5	R=4.0			

Note. χ^2=Chi-Square test; p=significance level; w=effect size; Δ=delta; R=variation range.

Forwards

By dividing the monthly frequencies into quarters into the groups of the 50 most productive and the 50 least productive forwards, the highest frequency in Q1 (n=18) and the lowest in Q4 (n=5) was found in the most productive forwards, which suggests a possible influence of the RAE. In contrast, the data distribution in individual quarters in the least productive forwards does not suggest any possible existence of influence of the RAE. The highest frequency was found in Q3 (n=14), the lowest in Q1 (n=11). Results of the statistical analysis of research data (Table 4) of the groups of both most productive and least productive forwards did not confirm the assumption of the influence of the RAE; the differences between the theoretical and empirical distribution of frequencies are statistically (p=0.06 and p=0.92) as well as materially (ES, w=0.22 and w=0.06) insignificant.

TABLE 4. Comparison of the 50 Most Productive and the 50 Least Productive Forwards

Position	Values	Q_1	Q_2	Q_3	Q_4	n	χ^2	p	w
Most productive forwards	Absolute	18	16	11	5	50			
	Relative	36.00%	32.00%	22.00%	10.00%	100%	7.31	0.06	0.22
	Δ	5.8	2.9	-1.9	-6.6	R=11.3			
Least Productive forwards	Absolute	11	12	14	13	50			
	Relative	22.00%	24.00%	28.00%	26.00%	100%	0.48	0.92	0.06
	Δ	-1.3	-1.2	1.1	1.3	R=2.6			

Note. x^2=Chi-Square test; p=significance level; w=effect size; Δ=delta; R=variation range.

Defensemen

The highest frequency in the group of most productive defensemen was found in Q1, Q2 (n=15), and the lowest in Q4 (n=9); the least productive defensemen had the highest frequency in Q2 (n=19), and the lowest in Q1 (n=9). The results of statistical analysis of research data (Table 5) of the groups of the most productive as well as least productive defensemen players enable to reject the assumption of the existence of influence of the RAE. The differences between the theoretical and empirical distribution of frequencies are both statistically (p=0.11 and p=0.25) and materially (ES, w=0.11 and w=0.17) insignificant.

TABLE 5. Comparison of the 50 Most Productive and the 50 Least Productive Defensemen

Position	Values	Q_1	Q_2	Q_3	Q_4	n	χ^2	p	w
Most productive defensemen	Absolute	15	15	11	9	50			
	Relative	30.00%	30.00%	22.00%	18.00%	100%	1.71	0.11	0.11
	Δ	-1.3	-1.2	-1.9	-2.6	R=5.4			
Least productive defensemen	Absolute	9	19	10	12	50			
	Relative	18.00%	38.00%	20.00%	24.00%	100%	4.15	0.25	0.17
	Δ	-3.3	5.9	-2.9	0.3	R=9.2			

Note. χ^2=Chi-Square test; p=significance level; w=effect size; Δ=delta; R=variation range.

Goaltenders

The distribution of absolute frequencies of birth date in individual months in the 24 best and the 24 worst goaltenders was again divided into individual quarters. The best goaltenders were found to have the highest frequency in Q1 (n=10); the zero frequency of birth date in the best goaltenders in Q4 is noteworthy. In the worst goaltenders group, the highest frequency was found in Q2 (n=8), the lowest in Q3 (n=4). Based on the results of the statistical analysis of research data (Table 6) in the group of the best goaltenders, the influence of the RAE cannot be rejected in terms of statistical (p=0.03) or material (w=0.35) significance. In contrast, the differences between the theoretical and empirical distribution of frequencies in the group of the worst goaltenders are both statistically (p=0.68) and materially (ES, w=0.14, small) insignificant.

TABLE 6. Comparison of the Best and Worst Goaltenders

Position	Values	Q_1	Q_2	Q_3	Q_4	n	χ^2	p	w
Best goaltenders	Absolute	10	8	6	0	24			
Relative	41.70%	33.30%	25.00%	0.00%	100%		8.88	0.03	0.35
Δ	4.1	1.6	-0.2	-5.6	R=9.7				
Worst goaltenders	Absolute	7	8	4	5	24			
Relative	29.20%	33.30%	16.70%	20.80%	100%		1.5	0.68	0.14
Δ	1.1	1.7	-2.2	-0.6	R=3.9				

Note. χ^2 =Chi-Square test; p=significance level; w=effect size; Δ=delta; R=variation.

Discussion

The analysis of the influence of the RAE in a group of ice hockey players (n =744) playing Czech youth ice hockey league (U15), showed a statistically significant difference in the distribution of birth data. Therefore,

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it can be stated that the influence of the RAE cannot be rejected in the observed group. The influence of the RAE can be rejected in the group of players from the three best and the three worst teams of the league: the statistical analyses did not show statistically significant differences. The assessment of the RAE for individual player's positions did not show statistically significant differences in forwards and defensemen (applies to both groups- most productive and least productive players). The influence of the RAE can be confirmed only in the group of the best goaltenders; in the group of the worst goaltenders, the influence can be rejected. It should be noted that in both cases for which the influence of the RAE cannot be rejected the ES showed only a small effect.

In the presented study, there are hockey players born in two consecutive years (in this case, 2001 and 2002= in the category of youth players. Hockey players always change after the season: the older year passes to the older players, and the category of U15 players is complemented by the players coming from the category of pupils. This exchange eliminates to some extent the problem that the players from the younger years would not otherwise be involved in the competition. This problem is pointed out in the study by Lames et al. (2008), who demonstrate it on the example of German youth women volleyball players. The age category in their case also includes two years, but the exchange occurs only once every two years, resulting in an extra-strong influence of the RAE.

The annual change in the investigated group of hockey players ensures that it is possible to examine the influence of the RAE in the entire group as a whole, even though it involves two birth years. As already mentioned, only one year from the pupil category is always transferred to the youth category; therefore, the influence of the RAE in younger players is the result of the selection process of this transition. The RAE analysis in the entire group has shown the influence of the RAE, although it is only a weak effect according to the effect size. The result achieved corresponds, for instance, with the study by Hancock et al. (2013), which points to the influence of the RAE in a sample of youth hockey players (n=25008), although states that this effect is no longer as strong as in the categories of pupils. Similar conclusions are given by Lames et al. (2008) on a group of young German hockey players, Sherar et al. (2007) on a group of young Canadian hockey players (n=281) or Lavoie et al. (2015) who also analysed the investigated group (n=436) by playing positions: the influence of the RAE could not be rejected in forwards and defensemen; the effect was rejected only in the goaltenders.

As mentioned in the introduction, there is currently no known study comparing the influence of the RAE in players of the best and worst teams in long-term national competition. Their conclusions mostly point to a significant influence of the RAE in the best teams, as confirmed for instance by González-Víllora, Pasto-Vicedo, and Cordente (2015) Andrade-Souza, Moniz, and Teoldo (2015) in football (soccer) in the U17 category; Saavedra, Gutiérrez Aguilar, Fernández Romero, Fernandéz Lastra, and Eiras Oliveira (2014) in basketball in the U16 and U17 categories; or Bjørndal, Luteberget, Till, and Holm (2018) in youth handball. The results obtained from the researched group of young hockey players indicate that the hockey players in the three best teams showed no influence of the RAE. Most of the investigated teams had hockey players born in the first three quarters, in which the frequencies were quite balanced. A more significant difference appeared between the third and fourth quarters. This result suggests that it is not necessary for teams to give much preference to older players to succeed in long-term competitions. The opposite situation was in the three worst teams: they had players born predominantly in the second to fourth quarters. The first quarter had the lowest frequency. At the same time, frequencies for individual quarters show that these teams did not have significantly younger players: most players were born in the second quarter of the year (i.e., in the first half of the year), but the teams failed to avert the final descent from the youth league.

An equally interesting result is that the influence of the RAE is rejected in relation to the productivity of both forward and defensemen hockey players, even though the p-value in the category of forwards approached the threshold of statistical significance (0.06). To explain this result, it is again necessary to remember that the category of youth players consists of two years: 2001 and 2002. The hockey players born in 2001 had been playing in the competition for their second year; compared to the 2002 birth year, they are older, more experienced, accustomed to the style, level and demands of the game in this age category. The productivity of the hockey players also often improves in the second year in comparison with the first year. In contrast, the hockey players born in 2002, although dominant in the category of pupils, may not achieve high productivity during the first year. It seems to be likely the consequence why the influence of the RAE is rejected in these groups. The influence is not rejected in the category of the best goaltenders, which means that the goaltenders born in the first months of 2000 or 2001 are given priority. The transition to the higher category does not seem to be such a change for the goaltenders as for the forwards and defensemen players. Therefore, even those who are in the youth category for the first year have a chance to succeed, even at the expense of older goaltenders that have been in this category for the second season.

Several solutions to the RAE have been proposed in the literature; a yearly rotation of athletes might work, which means no two-year age categories. The next recommendation is to create more age categories with smaller bandwidth (Helsen et al., 2005). This change would result in a smaller relative age difference and fewer physical differences between players within any specific age category. The issue of the RAE and the possible consequences of it for the sporting careers of young athletes, especially at the junior level, should also be considered in training programmes. It is essential to change the mentality of youth team coaches (Barnsley & Thompson, 1988). They should pay more attention to technical and tactical skills when selecting players as opposed to an over-reliance on physical characteristics, such as height (Helsen et al., 2005). Only coaches who are fully aware of the struggles of late-born children are prepared to offset the disappointment and setbacks these children encounter (Barnsley, & Thompson, 1988; Musch, & Grondin, 2001).

References

Abbott, A., & Collins, D. (2004). Eliminating the dichotomy between theory and practice in talent identification and development: considering the role of psychology. *Journal of Sport Science*, 22(5), 395-408. doi: 10.1080/02640410410001675324

Addona, V., & Yates, P. A. (2010). A closer look at the relative age effect in the National Hockey League. *Journal of Quantitative Analysis in Sports, 6*(4), 1-17. doi: 10.2202/1559-0410.1227

Agricola, A., Zháněl, J., & Hubáček, O. (2013). Relative age effect in junior tennis (male). *Acta Gymnica*, 43(1), 27-33. doi: 10.5507/ag.2013.003

Andrade-Souza, V. A., Moniz, F., & Teoldo, I. (2015). Relative age effect in FIFA U17 Emirates 2013 World Cup: analysis of players who effectively participated in the matches. Motriz: *Revista de Educação Física*, 21(4), 403-406. doi: 10.1590/s1980-65742015000400009

Arrieta, H., Torres-Unda, J., Gil, S. M., & Irazusta, J. (2016). Relative age effect and performance in the U16, U18 and U20 European Basketball Championships. *Journal of Sport Science*, 34(16), 1530-1534. doi: 10.1080/02640414.2015.1122204

Barnsley, R. H., & Thompson, A. H. (1988). Birthdate and success in minor hockey: The key to the NHL. *Canadian Journal of Behavioural Science,* 20(2), 167-176. doi: 10.1037/h0079927

Barnsley, R. H., Thompson, A. H., & Barnsley, P. E. (1985). Hockey success and birthdate: The relative age effect. *Canadian Association for Health, Physical Education, and Recreation,* 51(1), 23-28.

Bjerke, Ø., Pedersen, A. V., Aune, T. K., & Lorås, H. (2017). An inverse relative age effect in male alpine skiers at the absolute top level. *Frontiers of Psychology*, 8, 1-6. doi: 10.3389/fpsyg. 2017.01210

Bjørndal, C. T., Luteberget, L. S., Till, K., & Holm, S. (2018). The relative age effect in selection to international team matches in Norwegian handball. *PloS one*, 13(12), e0209288. doi: 10.1371/journal.pone.0209288

Cohen, J. (1988). *Statistical power analysis for the behavioural sciences*. 2nd ed. Hillsdale, NJ: Erlbaum.

Deaner, R. O., Lowen, A., & Cobley, S. (2012). Selection Bias in the National Hockey League: Relatively Younger Players Outperform Their Draft Slots. Available at *SSRN* 2148627. doi: 10.2139/ssrn.2148627

Ford, P. R., & Williams, M. A. (2011). No relative age effect in the birth dates of award-winning athletes in male professional team sports. *Research quarterly for exercise and sport*, 82(3), 570-573. doi: 10.1080/02701367.2011.10599790

Fumarco, L., Gibbs, B. G., Jarvis, J. A., & Rossi, G. (2017). The relative age effect reversal among the National Hockey League elite. *PloS one*, 12(8), e0182827. doi: 10.1371/journal. pone.0182827

Gibbs, B. G., Jarvis, J. A. & Dufur, M. J. (2012). The rise of the underdog? The relative age effect reversal among Canadian-born NHL hockey players: A reply to Nolan and Howell. *International Review for the Sociology of Sport*, 47(5), 644-649. doi: 10.1177/1012690211414343

González-Víllora, S., Pastor-Vicedo, J. C., & Cordente, D. (2015). Relative age effect in UEFA championship soccer players. *Journal of Human Kinetics*, 47(1), 237-248. doi: 10.1515/hukin-2015-0079

Grondin, S., Deshaies, P., & Nault, L. P. (1984). Trimestre de naissance et participation au hockey et au volleyball. *La Revue Quebecoise de l´Activite Physique*, 2: 97-103.

Hancock, D. J., Adler, A. L., & Côté, J. (2013). A proposed theoretical model to explain relative age effects in sport. *European Journal of Sport Science*, 13(6), 630-637. doi: 10. 1080/17461391.2013.775352

Helsen, W. F., Winckel, J. V., & Williams, A. M. (2005). The relative age effect in youth soccer across Europe. *Journal of Sport Sciences*, 23(6), 629-636. doi: 10.1080/02640410400021310

Hollings, S. C., Hume, P. A., & Hopkins, W. G. (2012). Relative-age effect on the competition outcomes at the World Youth and World Junior Athletic Championship. *European Journal of Sport Science*, 14(sup1). S456-S461. doi: 10.1080/17461391.2012.713007

Jiménez, I. P., & Pain, M. T. (2008). Relative age effect in Spanish association football: Its extent and implications for wasted potential. *Journal of Sports Science*, 26(10), 995-1003. doi: 10.1080/ 02640410801910285

Karcher, C., Ahmaidi, S., & Buchheit, M. (2014). Effect of birth date on playing time during international handball competitions with respect to playing positions. *Kinesiology*, 46(1), 23-32.

Lames, M., Augste, C., Dreckmann, C., Görsdorf, K., & Schimanski, M. (2008). Der "Relative Age Effect" (RAE): neue Hausaufgaben für den Sport. *Leistungssport*, 38(6), 4-9.

Lames, M., Augste, C., Dreckmann, C., Görsdorf, K., & Schimanski, M. (2009). The relative age effect in German youth sports: Football, handball and ice-hockey. E-Journal "*Bewegung und Training*".

Larouche, R., Laurencelle, L., Grondin, S., & Trudeau, F. (2010). Influence of birth quarter on the rate of physical activities and sports participation. *Journal of Sports Science*, 28(6), 627-631. doi: 10.1080/02640411003587392

Lavoie, F., Laurencelle, L., Grondin, S., & Trudeau, F. (2015). Temporal plasticity of the relative age effect in ice hockey: The case of elite minor players in Québec. *International Journal of Applied Sports Sciences*, 27(1), 14-25. doi: 10.24985/ijass.2015.27.1.14

Musch, J., & Grondin, S. (2001). Unequal competition as an impediment to personal development: A review of the relative age effect in sport. *Developmental Review*, 21(2), 147-167. doi: 10.1006/drev.2000.0516

Nolan, J. E., & Howell, G. (2010). Hockey success and birth date: The relative age effect revisited. International

 DOI 10.26773/mjssm.200905

Review for the Sociology of Sport, 45(4), 507-512. doi: 10.1177/1012690210371560

Parent-Harvey, C. I., Desjardins, C., & Harvey, E. J. (2014). Factors affecting the relative age effect in NHL athletes. *Canadian journal of surgery*, 57(3), 157-161. doi: 10.1503/cjs.008913

Saavedra, M., Gutiérrez Aguilar, Ó., Fernández Romero, J. J., Fernandéz Lastra, D., & Eiras Oliveira, G. (2014). Relative age effect in lower categories of international basketball. *International review for the sociology of sport*, 49: 526-535. doi: 10.1177/ 1012690212462832

Sherar, L. B., Baxter-Jones, A. D., Faulkner, R. A., & Russell, K. W. (2007). Do physical maturity and birth date predict talent in male youth ice hockey players? *Journal of Sport Science*, 25(8), 879-886. doi: 10.1080/02640410600908001

ORIGINAL SCIENTIFIC PAPER

A Combination of Exercise and Therapy with Cabergoline Attenuate Disturbances of Pituitary-Gonadal Hormones in Hyperprolactinemic Male Patients

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ABSTRACT This study aimed to investigate whether cabergoline therapy alone for six months or in combination with a light exercise programme for an additional three months can attenuate hyperprolactinemia in 13 male patients (range: 22 to 45 yrs.) through measuring pituitary-gonadal hormones including prolactin, follicle-stimulating hormone, luteinizing hormone, and total testosterone. The exercise programme consisted of walking, brisk walking, jogging, and running for three months, during which the intensity and duration of exercise were gradually increased. All the patients performed the exercise programme at 6.30 AM to exclude the effects of the circadian rhythm. The exercise programme was performed at an intensity below 160 beats per min to ensure filling of the heart with blood during ventricular diastole. Blood samples were collected from each patient on three occasions: before treatment, at the end of cabergoline therapy, and after the combination of light exercise and cabergoline. At the end of cabergoline therapy, descriptive data revealed that serum prolactin levels were decreased while the other hormones were increased but without returning to the normal range, except for one patient. However, at the end of the combination procedure, most hormones, namely prolactin and testosterone, were returned to the normal range in most patients. In conclusion, light exercise combined with cabergoline therapy for additional 3 months after 6 months of cabergoline therapy alone returned hormones in most patients to normal range probably due to improved mood and decreased hostility as a result of tuberoinfundibular pathway activity.

KEY WORDS hypogonadism, hypoglycaemia, tuberoinfundibular pathway, acetylcholine, galactorrhoea

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Introduction

Hyperprolactinemia is defined as the presence of abnormally high levels of serum prolactin (PRL) levels of above 20 ng/ml in men and above 25 ng/ml in women (Majumdar & Mangal, 2013). It affects the pituitary-gonadal axis function (Kulshreshtha et al., 2017; Toulis et al., 2018) through impaired binding of gonadotropins to the testes, which causes hypogonadism (Laufer, Margalioth, Livshin, Ben-David, & Schenker, 1981). Hypogonadism may decrease spermatogenesis (Panidis, Rousso, Skiadopoulos, Panidou, & Mamopoulos, 1997), resulting in reduced libido, impotence (EL-Beheiry, Souka, EL-Kamshoushi, Hussein, & EL-Sabah, 1988; Sperling & Bhatt, 2016), and anorgasmia.

Hyperprolactinemia is mainly caused by pituitary adenomas (i.e., prolactinomas) (Toulis et al., 2018). However, it can also be triggered by other etiopathological cases including liver disease (Laufer et al., 1981), thyroid disorders (Tirgar-Tabari, Sharbatdaran, Manafi-Afkham, & Montazeri, 2016; Sharma, Dutta, & Sharma, 2017), psychopharmacological drugs (Alpak et al., 2014; Kilic, Ozturk, Deveci, & Nrpinar, 2018; Palubska et al., 2017;

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Raveendranthan et al., 2018; Yancar-Demir & Sayin, 2014), and antidepressants (Kilic et al., 2018). In addition, hyperprolactinemia is related to a high-protein diet and hypoglycaemia (Palubska et al., 2017). Furthermore, stressful situations may also induce hyperprolactinemia (EL-Beheiry et al., 1988; Palubska et al., 2017).

Hyperprolactinemia can be asymptomatic (Alpak et al., 2014; Majumdar & Mangal, 2013) or be associated with clinical manifestations such as oligomenorrhea, amenorrhea, galactorrhoea (Dogan et al., 2016; Sperling & Bhatt, 2016), erectile dysfunction, gynecomastia (Alpak et al., 2014; Raveendranthan et al., 2018; Yancar-Demir & Sayin, 2014), oligospermia, azoospermia (Laufer et al., 1981), and infertility (Alpak et al., 2014; Tirgar-Tabari et al., 2016). Hence, there is an urgent need to treat hyperprolactinemia. Hyperprolactinemia can be inhibited by somatostatin, acetylcholine, norepinephrine (Majumdar & Mangal, 2013), gamma-aminobutyric acid (GABA) (Majumdar & Mangal, 2013; Nishimura et al., 1999), and dopamine (Gulleroglu et al., 2012; Khare et al., 2017; Nishimura et al., 1999; Yancar-Demir & Sayin, 2014). Significantly, the blockage of the tuberoinfundibular has been shown to cause hyperprolactinemia, since the activity of this pathway transmits dopamine from the arcuate nucleus to the pituitary gland, through which it inhibits the release of prolactin (Inci Kenar & Sozeri Varma, 2014). Cabergoline (CAB), a dopamine receptor agonist, can suppress PRL secretion (Dogan et al., 2016; Gulleroglu et al., 2012; Inci Kenar & Sozeri Varma, 2014; Khare et al., 2017; Raveendranthan et al., 2018; Sperling & Bhatt, 2016) and reduce adenoma size in the patients with prolactinomas (Dogan et al., 2016; Khare et al., 2017). CAB is associated with side effects, however, such as nausea, dizziness, nasal stuffiness, vomiting, headache (Majumdar & Mangal, 2013), blurred vision, and male sexual dysfunction (Buckworth, Dishman, O'Connor, & Tomporowski, 2013). Moreover, a recent research study reported that it might be unsafe, especially in cardiac valves, if the ingested dose is more than 3 mg a week (Khare et al., 2017). Dogan et al. (2016) demonstrated an increased risk of cardiovascular diseases (CVD) in patients with prolactinoma who suffered from hyperprolactinemia during therapy with a dopamine agonist.

Previous research reported a positive effect of dopamine receptor agonists on the normalization of PRL levels but not follicle-stimulating hormone (FSH), luteinizing hormone (LH), and total testosterone (TT) (Ishikawa, Kaneko, Ohashi, Nakagawa, & Hata, 1993). In addition, the treatment process with CAB for prolactinoma lasts for a relatively long duration (Ghadirian, Shirani, Ghazi-Mirsaeed, Mohebi, & Alimohamadi, 2018). Indeed, Sperling and Bhatt (2016) have shown no effects of 10 months of CAB therapy (0.25 mg twice per week) on PRL normalization. For this reason, alternative treatment methods could be examined, specifically those considering that the exercise intervention could attenuate depressant and hostility (Oldham et al., 2009) and suppress mood swings, which are all associated with elevated PRL levels. Moreover, since there is a link between stress and hyperprolactinemia, exercise may play a crucial role in stress reduction through exercise-induced dopamine release.

To the best of our knowledge, no study has been conducted to evaluate the pituitary-gonadal hormones by a combination of light exercise and CAB therapy in hyperprolactinaemic male patients. Therefore, this study aimed to investigate whether CAB therapy alone for six months or combined with light exercise for three months attenuate hyperprolactinemia in male patients by measuring pituitary-gonadal hormones, including PRL, FSH, LH, and TT. We hypothesized that CAB would decrease PRL levels, but a combination of CAB and light exercise would have a significant effect, probably due to activated blood circulation, thereby decreasing the elevated PRL concentration.

Methods

Participants

Thirteen male patients (n = 13) with hyperprolactinemia within the age range of 22 to 45 years (mean ± SD: 34.46±7.22 years) who visited the endocrinology outpatient clinics between February 2015 and October 2017 were evaluated endocrinologically. Five patients were married, and one of them was affected by macroprolactinoma. Patients were treated with different doses of CAB depending on their PRL levels. Thyroid function and 25-OH-Vitamin D were normal in all patients. The characteristics of patients (age, BMI, CAB dose, and duration of disease) are shown in Table 1.

Procedure

One day prior to the beginning of the study procedure, blood samples (8 ml) were collected from the median vein at 8:30 AM after overnight fasting (approximately 10 hours) to determine the baseline measurements (Table 2). Six months after CAB therapy alone, blood samples were collected following the same procedure during the baseline measurement. Additionally, in agreement with the physicians, CAB dose was roughly reduced to half after completion of the six months, based on each patient's dose. After that, all patients were involved in a light exercise programme for another three months. Each participant voluntarily provided written informed consent before participation in the present study. This study was approved in advance by the local scientific research committee (SS101-2019).

Exercise

The exercise programme consisted of walking, brisk walking, jogging, and running for three months, during which the intensity and duration of exercise were gradually increased (Table 3). The exercise was performed by all the patients at 6.30 AM to exclude the effects of their circadian rhythm and to ensure sufficient excre-

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TABLE 1. Patients' profile

Patients	Age (year)	BMI	CAB dose (mg/week)	Duration of disease (month)
Pt. No.1	45.1	28.32	1.75	29
Pt. No.2$_{MP}$	43.2	28.72	2.0	31
Pt. No.3	38.3	26.86	1. 5	23
Pt. No.4	28.2	24.22	1.25	19
Pt. No.5	34.4	23.78	1	16
Pt. No.6	40.7	27.11	1.75	25
Pt. No.7	37.6	24.38	1.5	24
Pt. No.8	29.4	22.64	1.25	21
Pt. No.9	32.0	23.88	1.5	19
Pt. No.10	41.3	26.60	1.75	26
Pt. No.11	22.4	24.34	1	18
Pt. No.12	24.6	23.24	1	16
Pt. No.13	30.9	23.12	1	20

Note. Pt. No. - Patient number; BMI - Body mass index; CAB - Cabergoline; MP - affected by macroprolactinoma.

tion of cortisol and thyroid hormones, which are responsible for the regulation of the body's metabolic ratio. The exercise was performed at an intensity below 160 beats per min to ensure the filling of the heart with blood during ventricular diastole. Heart rate (HR) was monitored by a pulse monitor (Samsung, Gear Sport). During these three months, the patients were asked to engage in either a bicycle ride or amusement swimming every Friday. Each patient ate an apple half an hour before the start of each exercise session for energy supply. At the end of the exercise programme, blood samples were collected and analysed for the hormonal responses. The exercise programme was designed during piloting with a well-trained athlete who experienced hyperprolactinemia for 24 months. During his disease, he was never engaged in any type of exercise due to general weakness and lack of energy.

After completing all tests, according to the social validation concept, the first author conducted focus group interviews with the patients. Social validation is designed to ensure that the programme considers views from the patients perspective (Barker et al., 2013) and to evaluate the satisfaction with a programme. During this stage, we mainly focused on the participants' satisfaction of the programme as it has been previously suggested (Page & Thelwell, 2013).

TABLE 2. Baseline measurements of the patient's pituitary-gonadal hormones

Patients	PRL (ng/ml) (NR: 4.0 - 15.20)	FSH (mIU/ml) (NR: 1.5 - 12.40)	LH (mIU/ml) (NR: 1.7 - 8.6)	TT (ng/dl) (NR: 249 - 836)
Pt. No.1	563	0.59	0.15	25.9
Pt. No.2	835	0.18	0.1	18.7
Pt. No.3	370	1.01	0.33	38
Pt. No.4	222	0.35	0.19	112
Pt. No.5	85	2.6*	2.1*	202
Pt. No.6	484	0.36	0.82	27.5
Pt. No.7	300	1.15	0.49	44
Pt. No.8	267	1.22	0.88	96
Pt. No.9	282	1.37	0.45	67
Pt. No.10	445	0.95	0.28	22.2
Pt. No.11	58	2.2*	2.6*	262*
Pt. No.12	188	1.8*	1.3	166
Pt. No.13	176	0.61	1.61	144

Note. Pt. No. - Patient number; PRL - Prolactin; FSH - Follicle-stimulating hormone; LH - Luteinizing hormone; TT - Total testosterone; * - Hormone value within normal range; NR - normal range.

All quantitative data were presented descriptively due to the wide range of the participants' characteristics, such as CAB dosage and PRL levels. Therefore, following the previous research (Barker et al., 2013; Buckworth et al., 2013), we only presented absolute changes in PRL, FSH, LH, and TT. The qualitative data, however, was reported verbatim as told by patients.

Prolactin, follicle-stimulating hormone, luteinizing hormone, and total testosterone were stored in a plain tube, centrifuged at 4500 RPM/10 min and quantitated by radioimmunoassay (Cobas E411; Roche, Germany).

TABLE 3. Exercise programme

Month 1	Week 1	Week 2	Week 3	Week 4
	8 min walking	8 min walking 2 min brisk walking	3 min walking 3 min brisk walking	10 min walking 4 min brisk walking
Month 2	**Week 1**	**Week 2**	**Week 3**	**Week 4**
	10 min walking 5 min brisk walking 1 min jogging	11 min walking 6 min brisk walking 1 min jogging	12 min walking 8 min brisk walking 1 min jogging	12 min walking 8 min brisk walking 2 min jogging
Month 3	**Week 1**	**Week 2**	**Week 3**	**Week 4**
	10 min walking 10 min brisk walking 4 min jogging	10 min walking 15 min brisk walking 1 min running	10 min walking 16 min brisk walking 2 min running	14 min walking 6 min brisk walking 4 min jogging 6 min running

Results

Table 4 illustrates the results of pituitary-gonadal hormones responses to CAB therapy alone for six months, followed by three months of light exercise combined with CAB therapy.

CAB therapy

Data revealed that serum PRL levels were decreased while the other hormones were increased but without returning to normal range, except one patient No. 11 who had his hormones back to normal range compared to the other 12 patients. Of relevance, patient No. 5 had FSH, LH, and TT back to the normal range but without any decreasing in the PRL level. FSH and LH levels were decreased to the normal range in patients No. 12 and 13. The FSH level was in the boarder lower limit in Patient No. 9.

Exercise and CAB

Data revealed that most patients returned their hormones, especially PRL and TT to normal range. However, Patients No. 1, 2, 6, and 10 failed to lower their hormones to the normal range. Significantly, Patient No. 4 had normal TT and LH levels but did not experience a decrease in PRL and an increase in FSH levels. Although PRL levels were abnormally high in Patients No. 3, 4, and 7, these levels are still considered to be less than 20 ng/ml; therefore, they were not near the point of hyperprolactinemia.

TABLE 4. Pituitary-gonadal hormones after 6 months of treatment with cabergoline therapy alone followed by 3 months of light exercise combined with cabergoline therapy

Patients	After therapy with CAB alone				After a combination of light exercise and CAB therapy			
	PRL	FSH	LH	TT	PRL	FSH	LH	TT
Pt. No.1	175	0.9	0.39	67.4	49	1.17	0.5	157
Pt. No.2	282	0.66	0.25	49.7	67	0.98	0.49	134
Pt. No.3	61	1.35	0.69	97	19.2#	1.69	1.90*	230
Pt. No.4	57	1.17*	0.53	169	17.4#	1.62	1.9*	281*
Pt. No.5	24.7	3.6*	2.4*	325*	8.8*	5.1*	3.8*	430*
Pt. No.6	133	0.51	1.1	74	33.6	1.29	2.77*	186
Pt. No.7	85	1.35	1.4	114	15.2#	2.08*	3.1*	294*
Pt. No.8	53	1.42	0.98	154	12.5*	2.25*	2.0*	331*
Pt. No.9	41	1.7*	1.02	133	14.8*	2.15*	1.9*	292*
Pt. No.10	96	1.29	0.55	69	27.1	1.87*	1.49	195
Pt. No.11	13.3*	2.5*	2.8*	319*	5.4*	5.01*	3.4*	482*
Pt. No.12	28.7	2.3*	1.9*	222	10.2*	3.1*	3.4*	400*
Pt. No.13	38.1	1.27*	2.09*	189	13.4*	2.03*	2.9*	373*

Note. Pt. No. - Patient number; PRL - Prolactin; FSH - Follicle-stimulating hormone; LH - Luteinizing hormone; TT - Total testosterone; CAB - Cabergoline; * - Hormone value within normal range; # - refers to serum PRL levels which are less than 20 ng/ml.

Discussion

This study investigated whether CAB therapy alone for six months or in combination with light exercise for an additional three months can attenuate hyperprolactinemia in male patients through measuring pituitary-gonadal hormones. We hypothesized that CAB would decrease PRL levels, but a combination of CAB and light

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exercise would have a significant effect, probably due to activated blood circulation thereby decreasing the elevated PRL concentration.

CAB therapy

This study revealed that the therapy with CAB alone alleviated the increased PRL levels and elevated the decreased FSH, LH, and TT in most of the patients. These results could be explained by the role of CAB in the activation of the tuberoinfundibular pathway, which regulates PRL secretion (Inci Kenar & Sezeri Varma, 2014; Yancar-Demir & Sayin, 2014) through dopamine binding to D2 receptors on lactotrophic cells (Alpak et al., 2014). The blockage of inhibitory neurons in the tuberoinfundibular pathway induces increased pituitary PRL secretion (Chapurin, Wang, Steinberg, & Jang, 2016).

In addition, CAB therapy returned hormones to normal ranges in only one patient. This result might be attributed to insufficient treatment duration based on the baseline values, especially PRL and TT. Sperling and Bhatt (2016) have shown that serum PRL levels decreased from 974 ng/ml to 568 ng/ml after CAB therapy (0.25 mg twice per week) in patients affected by pituitary macroadenoma (3.2 cm measure in adenoma size). The authors found that PRL at 10 months follow-up was decreased to 290 ng/ml, and thus they demonstrated the difficulty of attenuation in elevated serum PRL levels. Recently, Ghadirian et al. (2018) reported that 1 mg of CAB per week returned serum PRL levels from 358 ng/ml to 21 ng/ml after one year with CAB therapy in patients with macroprolactinoma, associated with intertumoral haemorrhage in a follow-up visit. In addition, Patient No. 11 showed enhanced levels of all hormones that were returned to normal ranges. These results could be explained by the long duration of treatment based on the baseline values of his hormones, which were the lowest values among patients before starting the CAB therapy.

Exercise and CAB

Data revealed that most patients, except No. 4, exhibited normalized hormonal levels, which might be attributed to the effect of light exercise in mood enhancement. Hyperprolactinemia is affected by mood. In addition to this, exercise could lessen the aggressive feelings that result from hyperprolactinemia, keeping the patient away from daily stress. In this regard, El-Beheiry et al. (1988) reported that 12% of patients with hyperprolactinemia were predisposed to stressful situations prior to their diagnosis with hyperprolactinemia. In the present study, five patients reported that they had had stressful lives, especially when the diagnosis of hyperprolactinemia was idiopathic. After beginning regular exercise, however, the patients felt happier with less stress. For instance, Patient 6 said: "I feel happy and strong again". Patient 10 added: "My life and my sexual life became much better".

Exercise has a positive biological effect on the pituitary-adrenocortical axis (Oldham, Zimmerman, & Hotfield, 2009); therefore, it can act as an inhibitor on disturbances that occur in the pituitary-gonadal axis. Another explanation by which exercise enhanced the mood of patients with hyperprolactinemia is that exercise induces excretion of β-endorphin, which is responsible for pain relief (Grossman & Sutton, 1985); thus, it improves headache associated with hyperprolactinemia. It has been documented that brain β-endorphin, which is defined as a suppressor of central fatigue, attenuates psychological stress (Yamashita & Yamamoto, 2014) and enhances social life. Furthermore, it has been shown that neurotransmitter dopamine is secreted at high levels during exercise (Abbiss & Laursen, 2005); which may improve muscle activation and enhance mood. While dopamine increases during physical activity, it may elicit motivation and increase arousal (Barker, Mellaliey, McCarthy, Jones, & Moran, 2013). For these reasons, we postulated that exercise might act as a "psychological booster" in hyperprolactinaemic patients.

It has been thought that very low-intensity exercise (e.g., jogging and brisk walking) could regulate the release of gonadotropin-releasing hormone (GnRH) secreted from the arcuate nucleus (Bailey, Davis, & Ahlborn, 1993; Abbiss & Laursen, 2005). This hormone is suppressed in patients with hyperprolactinemia, resulting in decreased FSH and LH (Majundar & Mangal, 2013; Sperling & Bhatt, 2016). Unfortunately, no research has been conducted into the effect of exercise on the attenuation of hyperprolactinemia. Therefore, further research is needed.

Significantly, Patient No. 2 has been affected by macroprolactinoma. This case could be too complicated for returning his hormone values to normal range. Pathologically, a tumour may compress the optic chiasm, which causes blurred vision (Dogan et al., 2016; Toulis et al., 2018). Moreover, a tumour causes inhibition of tuberoinfundibular dopamine pathway (Chapurin et al., 2016), resulting in increased pituitary PRL release. The other patients whose hormonal values did not return to their normal range after exercise might need a longer duration of the exercises based on the higher hormonal values they had. While PRL potentiates the LH to ensure spermatogenesis in testes by direct action on the Leydig cells (Laufer et al., 1981; Nishimura et al., 1999), PRL also inhibits the action of LH while present in abnormally high levels in the blood, resulting in a reduction of testosterone production (Nishimura et al., 1999) and positive feedback to the hypothalamus, which induced the suppression of GnRH release.

Finally, it could be crucial that patients believe that they can overcome this challenge due to exercise, for example, Patient 8 said: "I think that such exercises should be introduced as a regular treatment. Physicians must use them to treat people with hyperprolactinemia [...].I am saying this from my experience. It really works".

It is worth noting that those patients were overweight according to their BMI, which may indicate a link between high serum PRL levels and overweight or obesity. More research is needed regarding this. A limitation of the present study was that sperm count, sperm concentration, and sperm motility, as well as magnetic imaging resonance for the pituitary gland, were not measured.

Conclusion

In conclusion, light exercise combined with CAB therapy had a positive effect on the treatment of 13 male patients affected by hyperprolactinemia. This shows that light exercise combined with CAB therapy for additional three months after six months of CAB therapy alone returned prolactin, follicle-stimulating hormone, luteinizing hormone, and total testosterone in most patients to normal range probably due to improved mood and decreased hostility as a result of tuberoinfundibular pathway activity. We suggest introducing the light exercise programme to patients with hyperprolactinemia to enhance the other treatments efficacy further.

Highlights

- Light exercise, combined with CAB therapy, attenuates the high levels of serum PRL and increases the low levels of serum FSH, LH, and TT in male patients with hyperprolactinemia.
- Light exercise enhances mood and diminishes aggressive feelings in male patients with hyperprolactinemia.
- Light exercise combined with CAB therapy return PRL, FSH, LH, and TT to normal range in some patients with hyperprolactinemia.

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References

Abbiss, C. R., & Laursen, P. B. (2005). Models to explain fatigue during prolonged endurance cycling. *Sports Medicine*, 35(10), 865-898. doi: 10.2165/00007256-200535100-00004

Alpak, G., Unal, A., Bulbul, F., Akosy, I., Demir, B., & Svas, H. A. (2014). Hyperprolactinemia due to paliperdone palmitate and treatment with Aripiprazole. *Bulletin of Clinical Psychopharmacology*, 24(3), 253-256. doi: 10.5455/bcp.20131213042842

Bailey, S. P., Davis, J. M., & Ahlborn, E. N. (1993). Neuroendocrine and substrate responses to altered brain 5-HT activity during prolonged exercise to fatigue. *Journal of Applied Physiology*, 74(6), 3006-3012. doi: 10.1152/jappl.1993.74.6.3006

Barker, J. B., Mellaliey, S. D., McCarthy, P. J., Jones, M. V., & Moran, A. (2013). A review of single-case research in sport psychology 1997-2012: Research trends and future directions. *Journal of Applied Sport Psychology*, 25(1), 4-32. doi: 10.1080/10413200.2012.709579

Buckworth, J., Dishman, R. K., O'Connor, P. J., & Tomporowski, P. D. (2013). *Exercise psychology.* 2nd edition. Champaign, IL: Human Kinetics.

Chapurin, N., Wang, C., Steinberg, D. M., & Jang, D. W. (2016). Hyperprolactinemia secondary to allergic fungal sinusitis compressing the pituitary gland. *Case Reports in Otolaryngology*, 2016, 1-3. doi: 10.1155/2016/7260707

Dogan, A. B., Arduc, A., Tuna, M. M., Nasiroglu, I. N., Isik, S., Berker, D., & Guler, S. (2016). Evaluation of atherosclerosis after cessation of cabergoline therapy in patients with prolactinoma. *Anatolian Journal of Cardiology*, 16, 440-447. doi: 10.5152/AnatolJCardiol.2015.6416

EL-Beheiry, A., Souka, A., EL-Kamshoushi, A., Hussein, S., & EL-Sabah, K. (1988). Hyperprolactinemia and impotence. *Archives of Andrology*, 21, 211-214. doi: 10.3109/01485018808986743

Ghadirian, H., Shirani, M., Ghazi-Mirsaeed, S., Mohebi, S., & Alimohamadi, M. (2018). Pituitary apoplexy during treatment of prolactinoma with cabergoline. *Asian Journal Neurosurgery*, 13(1), 93-95. doi: 10.4103/1793-5482.181130

Grossman, A., & Sutton, J. R. (1985). Endorphins: What are they? How are they measured? What is their role in exercise? *Medicine & Science in Sports & Exercise*, 17, 74-81.

Gulleroglu, K., Olgac, A., Bayrakci, U., Erdogan, O., Kinik, S. T., & Baskin, E. (2012). Hyperprolactinemia as a rare cause of hypertension in chronic renal failure. *Renal Failure*, 34(6), 792-794. doi: 10.3109/0886022X.2012.672313

Inci Kenar, A. N., & Sozeri Varma, G. (2014). Hyperprolactinemia with Aripiprazole: a case report and review of the literature. *Bulletin of Clinical Psychopharmacology*, 24(3), 257-260. doi: 10.5455/bcp.20131021025639

Ishikawa, H., Kaneko, S., Ohashi, M., Nakagawa, K., & Hata, M. (1993). Retrograde ejaculation accompanying hyperprolactinemia. *Archives of Andrology*, 30, 153-155. doi: 10.3109/01485019308987749

Khare, S., Lila, A. R., Patil, R., Phadke, M., Kerkar, P., Bandgar, T., & Shah, N. S. (2017). Long-term cardiac (valvulopathy) safety of cebergoline in prolactinoma. *Indian Journal of Endocrinology and Metabolism*, 21(1), 154-159. doi: 10.4103/2230-8210.196010

Kilic, A., Ozturk, A., Deveci, E., & Nrpinar, I. (2018). Development of hyperprolactinemia induced by the addition of Bupropion to Venlafaxine XR treatment. *Bezmialem Science*, 6, 150-152. doi: 10.14235/

DOI 10.26773/mjssm.200906

bs.2018.1119

Kulshreshtha, B., Pahuja, I., Kothari, D., Sharma, N., Gupta, S., & Mittal, A. (2017). Menstrual cycle abnormalities in patients with prolactinoma and drug-induced hyperprolactinemia. *Indian Journal of Endocrinology and Metabolism*, 21(4), 545-550. doi: 10.4103/ijem.IJEM_515_16

Laufer, N., Margalioth, E. J, Livshin, J., Ben-David, M., & Schenker, J. G. (1981). Effect of bromocriptine treatment on male infertility associated with hyperprolactinemia. *Archives of Andrology*, 6, 343-346. doi: 10.3109/01485018108987547

Majumdar, A., & Mangal, N. S. (2013). Hyperprolactinemia. *Journal of Human Reproductive Sciences,* 6(3), 168-175. doi: 10.1007/978-81-322-1686-5_29

Nishimura, K., Matsumiya, K., Tsuboniwa, M., Koga, M., Miura, H., Tsujimura, A., Uchida, K., Kondoh, N., Kitamura, M., & Okuyama, A. (1999). Bromocriptine for infertile males with mild hyperprolactinemia: hormonal and spermatogenic effects. *Archives of Andrology*, 43, 207-213. doi: 10.1080/014850199262517

Oldham, J. S., Zimmerman, J. B., & Hotfield, B. D. (2019). Depression and anxiety disorders. In: Moore, G. E, Durstine, J. L., & Painter, P. L. (eds). Exercise management for persons with chronic disease and disabilities USA, American college of sports medicine: Human Kinetics (293-300). doi: 10.1249/01.mss.0000320868.98282.42

Page, J., & Thelwell, R. (2013). The value of social validation in single case methods in sport and exercise psychology. *Journal of Applied Sport Psychology*, 25(1), 61-71. doi: 10.1080/10413200.2012.663859

Palubska, S., Adamiak-Godlewska, A., Winkler, I., Romanek-Piva, K., Rechberger, T., & Gogacz, M. (2017). Hyperprolactinemia - a problem in patients from the reproductive period to the menopause. *Menopause Reviw*, 16(1), 1-7. doi: 10.5114/pm.2017.67364

Panidis, D., Rousso, D., Skiadopoulos, S., Panidou, E., & Mamopoulos, M. (1997). Evaluation of semen parameters in men with hyperprolactinemia induced by Metoclopramide. *Archives of Andrology*, 39, 237-242. doi: 10.3109/01485019708987922

Raveendranthan, D., Rao, N. P., Rao, M. G., Mangot, A. G., Varambally, S., Kesavan, M., Venkatasubramanian, G., & Gangadhar, B. N. (2018). Add-on Aripiprazole for atypical antipsychotic-induced-clinically significant hyperprolactinemia. *Indian Journal of Psychological Medicine*, 40(1), 38-40. doi: 10.4103/IJPSYM.IJPSYM_147_17

Sharma, N., Dutta, D., & Sharma, L. K. (2017). Hyperpolactinemia in children with subclinical hypothyroidism. *Journal of Clinical Research in Pediatric Endocrinology*, 9(4), 350-354. DOI: 10.4274/jcrpe.4536

Sperling, S., & Bhatt, H. (2016). Prolactinoma: a massive effect on bone mineral density in a young patient. *Case Reports in Endocrinology*, 2016, 1-3. doi: 10.1155/2016/6312621

Tirgar-Tabari, S., Sharbatdaran, M., Manafi-Afkham, S., & Montazeri, M. (2016). Hyperprolactinemia and hirsutism in patients without polycyctic ovary syndrome. *International Journal of Trichology*, 8(3), 130-134. doi: 10.4103/0974-7753.188998

Toulis, K. A., Robbins, T., Reddy, N., Balachandra, K., Gokhale, H., Cheng, K. K., Karavitaki, N., Wass, J., & Nirantharakumar, K. (2018). Males with prolactinoma are at increased risk of incident cardiovascular disease. *Clinical Endocrinology*, 88, 71-76. DOI: 10.1111/cen.13498

Yamashita, M., & Yamamoto, T. (2014). Tryptophan and kynurenic acid may produce an amplified effect in central fatigue induced by chronic sleep disorder. *International Journal of Tryptophan Research,* 7, 9-14. doi: 10.4137/IJTR.SI4084

Yancar-Demir, E., & Sayin, A. (2014). Prolongation of hyperprolactinemia by Clozapine: a case report. *Bulletin of Clinical Psychopharmacology*, 24(4), 371-375. doi: 10.5455/bcp.20131127065702

Quadriceps Muscle Oxygenation during a Maximum Stress Test in Middle-Aged Athletes

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ABSTRACT Determining oxygen muscle saturation (SmO_2) using near-infrared spectroscopy (NIRS) is an emerging technique that is increasingly used in sports science; therefore, it is necessary to know its results in different population groups. We analysed it in a group of recreational participants in Nordic Walking. The purpose of this research was to analyse the SmO_2 values obtained at various times from testing in a group of athletes over 45. Thirty athletes (18 males) with a mean age of 51.3 years completed a maximal exercise testing in treadmill according to a modified Bruce protocol on a ramp. The electrocardiogram was continuously monitored. We measured VO_2max (Metalyzer 3B). In addition, we placed a Humon Hex device on the right thigh to measure quadriceps oxygenation. Heart rate, VO_2, and SmO_2 ratios were obtained based on the exercise intensity. We obtained a SmO_2 at startup of 63.3%, standard deviation (SD) 9.2%; SmO_2 declined 61.8%, SD 11.4%; SmO_2 in VO_2max 57.4% SD 10.2% and SmO_2 5 minutes after starting recovery 72.5% SD7.9%. There was a relationship between ventilatory thresholds and variations in SmO_2. There were no significant differences between the sexes. We could conclude that the minimum values of SmO_2 were related to the VO_2 max. During the recovery phase, the values were higher than at rest. The information obtained could be used to control and plan the training.

KEY WORDS nordic walking, muscle oxygenation, maximal exercise testing

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Introduction

Haemoglobin is the oxygen transport protein from the lungs to the muscles. Oxygen intake is a key factor for muscle metabolism, maintaining physical activity and athletic performance (Hearris, Hammond, Fell, & Morton, 2018). In sports science, there are several methods used to evaluate muscle metabolism and plan training sessions, some of which are based on the measurement of lactic acid in capillary blood and others on the study of spirometric variables related to maximal oxygen uptake (VO_2max) (Hawkins, Raven, Snell, Stray-Gundersen & Levine, 2007) and determining ventilatory thresholds (Lam & Ravussin, 2016). Recently, measurements of oxygen muscle saturation (SmO_2) are also being used (Crum, O'Connor, Van Loo, Valckx, & Stannard 2017).

SmO_2 is obtained non-invasively with Near-Infrared Spectroscopy (NIRS) via the placement of skin devices (Hamaoka & McCully, 2019). This technique allows obtaining immediately, on a screen, the percentage of muscle saturation of oxygen; the current devices comprise a small receiver that is placed with a belt surrounding the body segment to be assessed. The most commonly used location is in the thigh in order to measure the SmO_2 of the quadriceps (vastus lateralis) (Grassi & Quaresima, 2016). The data are sent to a computer application that can be installed on a watch, smartphone, or tablet that can be consulted by the athlete or researcher. The information received enables adapting the intensity of the exercise according to a specific objective, similar to what is done with a heart rate monitor (Ferrrari, Muthalib, & Quaresima, 2011).

NIRS technology for measuring the SmO_2 is validated and has been used primarily by elite athletes (Chang et al., 2019), but there is little evidence of its use in older people who practice physical activity to improve their health (Gepner, Wells, & Gordon, 2019). For physical exercise to produce benefits, it is known that it is necessary to be

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performed with adequate frequency and intensity (Murphy, Lahart, Carlin, & Murtagh, 2019). Therefore, the control of this intensity of physical activity and the possibility of regulating it according to the characteristics of each person is essential to increase the benefits of training (Wewege, Thom, Rye, & Parmenter, 2018).

The most recommended physical exercise for the elderly is walking for several hours, several days a week, with moderate intensity (Slaght, Sénéchal, Hrubeniuk, Mayo, & Bouchard, 2017). A modification of the usual walk is "Nordic walking" (NW), which is a specific sport discipline with its own rules and competitions (Padulo et al., 2018). In this sport, poles and a specific technique for walking are used, maintaining an upright posture and increasing the speed and intensity of effort (Mocera, Aquilino, & Somà, 2018). NW is increasingly recommended for older people because of its relative ease, accessibility and health effects (Tschentscher, Niederseer, & Niebauer, 2013). If NW practitioners monitor the pace of walking, depending on their specific abilities, they improve the effects of exercise (Takeshima et al., 2013).

Measuring SmO_2 can be a good way of controlling the intensity of exercise and adapting it to the needs of the person (Wilkinson et al., 2019). To accomplish this, it would be interesting to have studies that confirm the usefulness of SmO_2, relating it to the data obtained with traditional techniques of performance assessment, assuming the peculiar responses of these subjects. Thus, the objective of our work is to analyse the values of SmO_2 obtained at various times in a maximal exercise stress test in a group of recreational athletes over 45 years old who practice NW.

Methods

The study population was 30 adults over 45 years old, recreational athletes of the clubs "Nordic Walking Murcia" and "Marcha Nórdica Costa Blanca Elx " (Spain), with at least two years of experience in NW (mean 2.9±1.0 years). Participants walked three days a week, about 10 km each day.

All participants provided written, informed consent for their participation in the study. The inclusion criteria were to have a minimum of one year of experience, excluding those suffering from illnesses, injuries, or deficiencies that prevented them from taking the stress test. The study was conducted according to the principles of the Declaration of Helsinki and was approved by the Research Ethics Commission of the University of Murcia.

First, cardiovascular examinations at rest were performed with the athletes in supine decubitus, assessing cardiac auscultation, blood pressure, and electrocardiogram (EKG). The electrodes were maintained to collect the EKG trace throughout the stress test. Heart rate (HR) and EKG recording were obtained with a Cube® cardioline electrocardiograph. Subsequently, a Humon Hex® device was placed on the thigh of the dominant side, on the vastus lateralis (Figure 1). To display the information of the SmO_2, exercise time and heart rate (HR), the Humon Hex® was synchronized with a tablet with the Humon app.

FIGURE 1. Start of the test. Humon Hex® placed on right thigh

The stress test was performed on a treadmill (model run7411®) with a modified Bruce ramp protocol. The test ended when the subject could no longer run and gestured with his hand and began the recovery phase by slowing down (3 minutes to 4 km/hour). The tests were considered to be maximum and valid when 85% of the theoretical maximum heart rate (220-age) was exceeded, and the respiratory ratio (RER) was greater than 1.15 (Howley 1995).

During the stress test, the subjects breathed through a mask connected to the gas analyser (Metalyzer 3b®, Cortex). All gas exchange parameters were measured during breathing and averaged every 30 seconds. The method used for determining VO_2 max was to reach the plateau of oxygen consumption (Fletcher 2009). All

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tests were carried out under similar environmental conditions.

The values of SmO_2 were obtained from the curves SmO_2/exercise time (Figure 2) provided by the Humon Hex app®, selecting the data for the following phases: 1) prior to the exercise; (2) decline phase: at the time of the sharp decline or descent of the SmO_2 (Humon Hex® indicates this situation with a change in colour (orange); 3) the maximum descent that coincides with the maximum exercise intensity and with the VO_2 max); and 4) recovery phase: after the exercise, when the normal values are retrieved (indicated by another colour change on the graph, from blue to green).

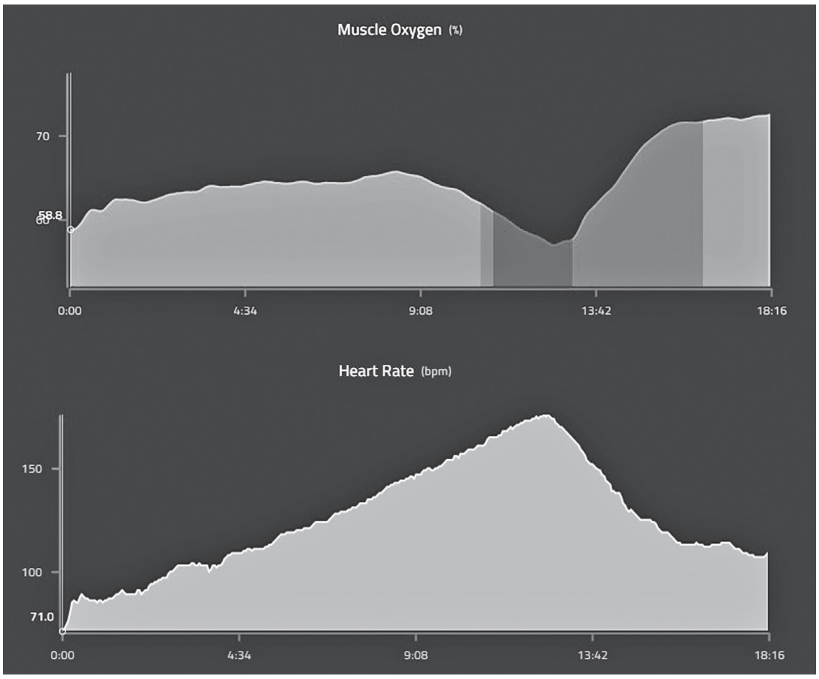

FIGURE 2. Heart rate and SmO_2/exercise time curves

All statistical analyses were conducted using SPSS software version 24.0 (Chicago, IL, USA). Quantitative variables have been described with mean, standard deviation (SD) and coefficient of variation (CV=SD/mean ×100) and qualitative by absolute frequency and percentage. The normal distribution of the variables was checked by the Shapiro-Wilk test, and the equal variances using the Levene test. Comparison of means of independent variables and intergroups (men and women) was performed using the t-student test; a paired samples t-test was used to compare the means of related variables. The relationship between variables was studied using Pearson's correlation analysis. A level of significance of $p<0.05$ was considered.

Results

In Table 1, the characteristics of the population separated by sex (18 male and 12 females) are shown; only differences between men and women in size, weight, and VO_2max are noted. Coefficients of variation indicate that the population is homogeneous.

TABLE 1. Characteristics of the population (males n=18; females n=12)

	Gender	Mean	Standard deviation	Variation Coefficient (%)	Significance (p value)
Age (years)	Males	50.06	6.64	13.3	0.074
	Females	53.75	2.18	4.1	
Height (m)	Males	1.78	0.05	2.8	0.000
	Females	1.65	0.04	2.4	
Weight (Kg)	Males	81.08	8.99	11.1	0.000
	Females	67.31	7.16	10.6	
BMI (Kg/m²)	Males	25.52	2.71	10.6	0.423
	Females	24.72	2.54	10.3	
%HRmax prediction	Males	99.19	7.93	8.0	0.477
	Females	96.79	10.29	10.6	
VO_2 max (ml/Kg/min)	Males	33.50	8.54	25.5	0.024
	Females	27.08	4.52	16.7	

Note. HR: Heart rate; SmO2 muscle oxygen saturation; VO2: oxygen consumption.

The comparison between groups by gender of SmO_2 and heart rate in each of the four stages in which the evolution of SmO_2 has been divided during the effort shows no differences between males and females (Table 2). Likewise, the percentage of HR at the time of the decline from the maximum reached also shows no differences between sexes. Males show slightly higher values at the onset of decline; there are also no differences between the sexes in the SmO_2 in maximum effort and recovery.

TABLE 2. Comparison, between genders (males n=18; females n=12), of SmO_2 and HR in each of the phases

	Gender	Mean	Standard deviation	Variation Coefficient (%)	Significance (p-value)
% SmO_2 Prior to the exercise	Males	62.73	7.42	11.8	0.665
	Females	64.27	11.86	18.5	
% SmO_2 Decline phase	Males	63.11	9.10	14.4	0.432
	Females	59.47	15.17	25.5	
% SmO_2 Maximum exercise	Males	59.51	9.27	15.6	0.161
	Females	53.97	11.20	20.8	
% SmO_2 Recovery phase	Males	71.54	7.98	11.2	0.413
	Females	74.01	7.93	10.7	
HR (lat/min) Prior to the exercise	Males	75.83	10.23	13.5	0.328
	Females	72.33	8.05	11.1	
HR (lat/min) Decline phase	Males	143.11	29.50	20.6	0.445
	Females	134.60	24.28	18.0	
HR (l/m) Maximum exercise	Males	169.20	14.22	8.4	0.180
	Females	160.8	18.35	12.1	
HR (lat/min) Recovery phase	Males	120.11	18.04	15.0	0.174
	Females	111.00	16.68	15.0	
% HR decline/HR maximum exercise	Males	83.83	13.51	16.11	0.740
	Females	82.17	10.55	12.84	
Minutes to decline phase	Males	8.63	3.16	36.58	0.072
	Females	6.56	1.98	30.21	
Minutes to maximum exercise	Males	11.62	2.97	25.54	0.166
	Females	10.04	1.98	19.72	
Minutes to recovery phase	Males	5.31	3.06	57.61	0.321
	Females	4.12	2.13	51.73	

Note. HR: Heart ratio; SmO_2 muscle oxygen saturation; VO_2: Oxygen consumption.

Figure 3 shows the evolution of the SmO_2, VO_2, and HR throughout the stress test. VO_2 and HR increase in the early stages and decrease during the recovery phase; the situation is reversed with SmO_2.

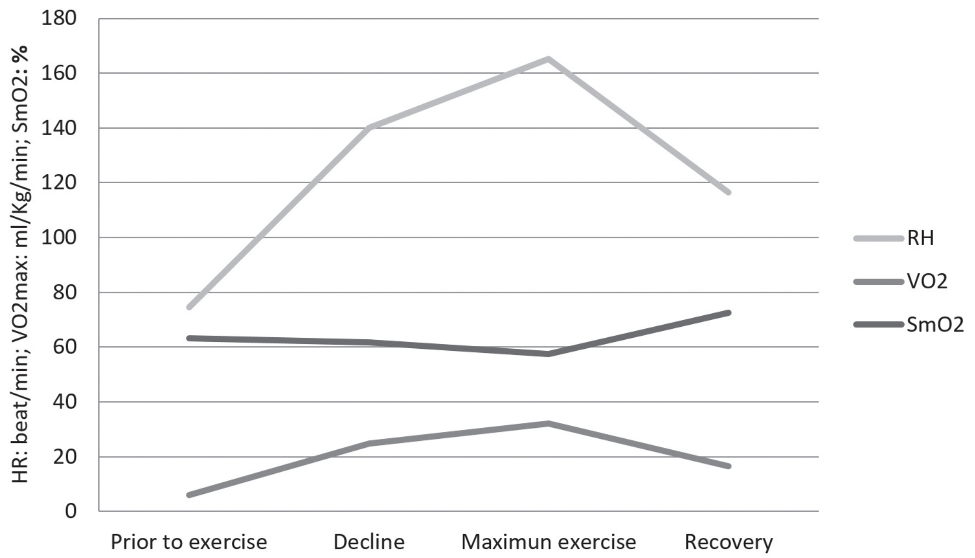

FIGURE 3. Evolution of SmO_2, Rate Heart (RH) and (Oxygen consumption (VO_2)

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When the SmO_2 with RER, HR, and VO_2 is correlated in each of the phases, only a significant correlation is observed between all of them in the recovery phase. With the maximum effort, SmO_2 is correlated with the RER; higher RER correlates with lower SmO_2 (Table 3).

TABLE 3. Correlations between SmO_2 and ergometry values

		SmO_2 Decline	SmO_2 maximum exercise	SmO_2 Recovery phase
RER	Pearson correlation	-0.360	-0.454	-0.789
	Significance (p value)	0.065	0.039*	0.000*
HR	Pearson correlation	-0.125	-0.021	-0.391
	Significance (p value)	0.533	0.913	0.033*
VO_2	Pearson correlation	-0.266	-0.193	-0.486
	Significance (p value)	0.180	0.315	0.006*

Note. RER: Respiratory Exchange Ratio (Respiratory Quotient); HR: Heart rate; SmO_2 muscle oxygen saturation; VO_2: oxygen consumption; * p<0.05.

In contrast, the correlations between pre-exercise SmO_2 and the other saturation measures show significant values, with SmO_2 decline phase (r=0.875; p<0.000); with SmO_2 in the maximum effort (r=0.851; p<0.000) and with SmO_2 in the recovery phase (r=0.816; p<0.000).

There are significant differences between SmO_2 prior to the test and that obtained in the maximum effort (t-6.061; p<0.000), also with the SmO_2 of the recovery phase (t-9.350; p<0.000); but there are differences with the SmO_2 obtained at the beginning of the decline (t-1.995; p-0.056).

The SmO_2 at the time of decline does not maintain a correlation with the percentage of the maximum HR reached (r=-0.34; p=0.868), nor with the exercise time to that point (r=0.048; p=0.813).

Discussion

Measuring SmO_2 using NIRS devices is a recently used technique in the assessment of physical condition. For this reason, we have done this work to provide new knowledge about its use and its results. We used a Humon Hex® device in a population of subjects over 45 years of age, practitioners of Nordic Walking, to measure the SmO_2 of the quadriceps while performing a stress test on a treadmill, the validity of this device has been previously verified by Farzam, Starkweather, and Franceschini (2018). We have divided the stress test into four phases and compared the values of men and women without entering differences between the sexes.

The stress test has been performed with a modified Bruce ramp protocol because it manages to reach the exhaustion of the subject without having to run. Furthermore, this test is more similar to NW than the protocols based on speed increase (Pellegrini, 2018).

Most studies with NIRS have been done with young male athletes, while we have studied middle-aged adults, comparing both sexes, allowing us to increase the information available on SmO_2 (Seshadri, et al., 2019). Our results indicate, as in the study of Wilkinson et al. (2019), that as exercise intensity increases, a decrease in SmO_2 occurs, to a point at which an inflection appears. This is shown in the tablet graphics with a colour change (Humon, 2020). Other authors relate this inflection to the ventilatory threshold (Karatzano et al., 2010), although they indicate that there is a great individual variability due to fat percentage, age, and physical activity (Zwaard et al., 2016).

We have also found that the exercise time in which this change occurs is different among subjects, showing a medium coefficient of variation (30-36%), but without significant differences between the sexes; this could be related to the physical condition of each person (Takaishi et al., 2002).

From the tipping point, the SmO_2 continues to decrease, as the intensity of the exercise progresses, reaching exhaustion. We have seen that the minimum value of SmO_2 also appears at the time when the VO_2max is achieved. Inglis, Iannetta & Murias (2017) state that this situation would not indicate the upper limit of O_2 extraction and that there could be a reserve area. With the maximum exercise, our subjects had values higher than those cited by Yamamoto et al. (2014).

At the beginning of recovery, after the point of maximum effort, the heart rate begins to drop, at which point it is observed that SmO_2 increases gradually, reaching values higher than the initial ones. This effect is similar to the "super-compensation principle" of training (Doering, Coxa, Aretac, & Coffeya, 2019). Not all authors value this phase of recovery (Contreras Briceño et al., 2019); however, we think it may be interesting when using the Humon Hex® device to conduct training and schedule the return to calm.

One limitation of this work is that it has been done on a laboratory test in which participants were not able to use the poles and is, therefore, not fully comparable to the actual activity of the NW.

The usefulness of this study is the applicability of the use of the Humnon Hex® device in the training of Nordic walking practitioners. They can adjust the intensity of their effort to the signals received and avoid depletion, decreasing intensity when SmO_2 values reach the tipping point. The advantage of using the device instead of VO_2max is that there is no need to pre-perform a stress test to regulate exercise intensity.

We conclude that there are no differences between the sexes. The evolution of SmO_2 is opposite to that of heart rate and oxygen consumption, decreasing during exercise and increasing in recovery.

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References
Chang, S. C., Adami, A., Lin HC, Lin, Y. C., Chen, C. P., Fu, T. C., … Huang, S. C. (2019). Relationship between maximal incremental and high-intensity interval exercise performance in elite athletes. *bioRxiv,* 856237. Retrieved 11/30, 2019, from https://www.biorxiv.org/content/10.1101/856237v1

Contreras-Briceño, F., Espinosa-Ramirez, M., Hevia, G., Llambias, D., Carrasco M., Cerda, F., … Viscor, G. (2019). Reliability of NIRS portable device for measuring intercostal muscles oxygenation during exercise. *Journal of Sports Sciences, 37*(23), 2653-2659. doi: 10.1080/02640414.2019.1653422

Crum, E. M., O'Connor, W. J., Van Loo, L., Valckx, M. & Stannard, S. R. (2017). Validity and reliability of the Moxy oxygen monitor during incremental cycling exercise. *European Journal of Sport Science, 17(8)*, 1037-1043. doi: 10.1080/17461391.2017.1330899

Doering, T. M., Coxa, G. R., Aretac, J. L., & Coffeya,V. G. (2019). Repeated muscle glycogen supercompensation with four days recovery between exhaustive exercise. *Journal of Science and Medicine in Sport, 22*, 907–911. doi: 10.1016/j.jsams.2019.03.009

Farzam, P., Starkweather, Z., & Franceschini, M. A. (2018). Validation of a novel wearable, wireless technology to estimate oxygen levels and lactate threshold power in the exercising muscle. *Physiological Reports, 6 (7),* e13664. doi: 10.14814/phy2.13664

Ferrari, M., Muthalib, M., & Quaresima, V. (2011). The use of near-infrared spectroscopy in understanding skeletal muscle physiology: recent developments. *Philosophical Transactions of Royal Society A*, *369*: 4577-4590. doi: 10.1098/rsta.2011.0230

Fletcher, J. R., Esau, S. P., & MacIntosh, B. R. (2009) . Economy of running: beyond the measurement of oxygen uptake. *Journal Applied Physiology, 107*, 1918-1922. doi: 10.1152/japplphysiol.00307.2009

Gepner, Y., Wells, A. J., Gordon, J. A., Arroyo, E., Varanoske, A. N., Coker, N. A. … Hoffmann, J.R., (2019). Differences in muscle oxygenation between young and middle-aged recreationally active men during high-volume resistance exercise. *Kinesiology.* 51(1), 3-11. doi: 10.26582/k.51.1.4

Grassi, B., & Quaresima, V. (2016). Near-infrared spectroscopy and skeletal muscle oxidative function in vivo in health and disease: a review from an exercise physiology perspective. *Journal of Biomedical Optics*, *21*(9): 091313. doi: 10.1117/1.JBO.21.9.091313.

Hamaoka, T,. & McCully, K. K. (2019). Review of early development of near-infrared spectroscopy and recent advancement of studies on muscle oxygenation and oxidative metabolism. *The Journal of Physiological Sciences,* 69(1), 799–811. doi: 10.1007/s12576-019-00697-2

Hawkins, M. N., Raven, P. B., Snell, P. G., Stray-Gundersen, J., & Levine, B. D. (2007). Maximal Oxygen Uptake as a Parametric Measure of Cardiorespiratory Capacity. *Medicine & Science in Sports & Exercise, 39 (1),* 103-107. doi: 10.1249/01.mss.0000241641.75101.64

Hearris, M. A., Hammond, K. M., Fell, J. M., & Morton, J. P. (2018). Regulation of muscle glycogen metabolism during exercise: inplications for endurance performance and training adaptations. *Nutrients,* 10, 298. doi: 10.3390/nu10030298

Howley, E. T., Bassett, D. R., & Welch, H. G. (1995). Criteria for maximal oxygen uptake: review and commentary. *Medicine and Science in Sports and Exercise,* 27(1), 1292-1292.

Humon io (2020). The Humon training zones. Retrieved 02/03, 2020, from https://humon.io/use-case/

Inglis, E.C., Iannetta, D., & Murias, J. M. (2017). The plateau in the NIRS derived (HHb) signal near the end of a ramp incremental test does not indicate the upper limit of O_2 extraction in the *vastus lateralis*. *American Journal of Physiology Regulatory Integrative and Comparative Physiology, 313,* R723–R729. doi: 10.1152/ajpregu.00261.2017

Karatzanos, E., Paradisis, G., Zacharogiannis, E., Tziortzis, S.,& Nanas, S. (2010). Assessment of ventilatory threshold using near-infrared spectroscopy on the gastrocnemius muscle during treadmill running. *International Journal of Industrial Ergonomics, 40,* 206–211. doi: 10.1016/j.ergon.2009.02.003

Lam, Y. Y., & Ravussin, E., (2016). Analysis of energy metabolism in humans: A review of methodologies. *Molecular Metabolism, 5*(11), 1057-1071. doi:10.1016/j.molmet.2016.09.005

Mocera, F., Aquilino, G., & Somà, A. (2018). Nordic walking performance analysis with an integrated monitoring system. *Sensors*, *18*(5), 1505. doi: 10.3390/s18051505

Murphy, M. H., Lahart, I., Carlin, A., & Murtagh, E. (2019). The Effects of Continuous Compared to Accumulated Exercise on Health: A Meta-Analytic Review. *Sports Medicine*. 49(1), 1585-1607. doi: 10.1007/s40279-019-01145-2

Padulo, J., Iuliano, E., Dello Iacono, A., Milic, M., Rizzi, M., & Ardigò, L. P. (2018). Nordic walking versus natural walking: an easy approach to comparing metabolic demands. *International Journal of Performance Analysis in Sport*, *18*(5), 686-692. doi: 10.1080/24748668.2018.1514565

Pellegrin, B., Boccia, G., Zoppirolli, C., Rosa, R., Stella, F., Bortolan, L., … Schena, F. (2018). Muscular and metabolic responses to different Nordic walking techniques, when style matters. *PLoS ONE 13(4):* e0195438. doi: 10.1371/journal.pone.019543

Seshadri, D. R., Li, R. T., Voos, J. E., Rowbottom, J. R., Alfes, C. M., Zorman C. A., & Drummond, C. K. (2019). Wearable sensors for monitoring the internal and external workload of the athlete. *NPJ Digital Medicine,* 2(71). doi :10.1038/s41746-019-0149-2

Slaght, J., Sénéchal, M., Hrubeniuk, T. J., Mayo, A., & Bouchard, D. R. (2017). Walking cadence to exercise at moderate intensity for adults: a systematic review. *Journal of Sports Medicine, 4641203*. doi: 10.1155/2017/4641203.

Takaishi,T., Sugiura, T., Katayama, K., Sato, Y., Shima, N., Yamamoto, T., & Moritani, T. (2002). Changes in blood volume and oxygenation level in a working muscle during a crank cycle. *Medicine & Science in Sports & Exercise, 34*(3), 520-528. doi: 10.1097/00005768-200203000-00020

Takeshima, N., Islam, M. M., Rogers, M. E., Rogers, N. L., Sengoku, N., Koizumi, D., ... Naruse, A. (2013). Effects of nordic walking compared to conventional walking and band-based resistance exercise on fitness in older adults. *Journal of Sports Science and Medicine, 12***,** 422-430.

Tschentscher, M., Niederseer, D., & Niebauer, J. (2013). Health benefits of Nordic walking: a systematic review. *American Journal of Preventive Medicine. 44(1*), 76-84. doi: 10.1016/j.amepre.2012.09.043

van der Zwaard, S., Jaspers, R. T., Blokland, I. J., Achterberg, C., Visser, J. M., den Uil, A.R., … DE Ruiter, C.J. (2016). Oxygenation threshold derived from near-infrared spectroscopy: reliability and its relationship with the first ventilatory threshold. *PLoS ONE, 11(9)*, e0162914. doi: 10.1371/journal.pone.0162914

Wewege, M. A., Thom, J. M., Rye, K. A., & Parmenter, B. J. (2018). Aerobic, resistance or combined training: A systematic review and meta-analysis of exercise to reduce cardiovascular risk in adults with metabolic syndrome. *Atherosclerosis,* 274 (1), 162-171. doi: 10.1016/j.atherosclerosis.2018.05.002

Wilkinson, T. J, White, A. E. M., Nixon, D, G, D., Gould, D. W., Watson, E., L. & Smith, A. C. (2019). Characterising skeletal muscle hemoglobin saturation during exercise using near-infrared spectroscopy in chronic kidney disease. *Clinical and Experimental Nephrology 23,* 32-42. doi: 10.1007/s10157-018-1612-0

Yamamoto, J., Harada T., & Okada, A. (2014). Difference in Physiological Components of VO_2 Max during Incremental and Constant Exercise Protocols for the Cardiopulmonary Exercise Test. *Journal of Physical Therapy Science, 26*, 1283–1286. doi: 10.1589/jpts.26.1283

ORIGINAL SCIENTIFIC PAPER

Equine Assisted Activities Have Positive Effects on Children with Autism Spectrum Disorder and Family Functioning

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ABSTRACT Equine-assisted activities (EAA) have emerged as a new method of treatment for children diagnosed with autism spectrum disorder (ASD) in recent years. This study aimed to evaluate the effectiveness of EAA in the areas of social functioning, autistic behaviours, family functioning, and clinical severity for children diagnosed with ASD. The participants were 24 children (4-12 years old) diagnosed with ASD and their mothers. Subjects were randomized into two groups, and the programme consisted of eight sessions of EAA. A social communication questionnaire and clinical global impression scale were used to evaluate the severity of autistic behaviours, and family assessment device was used for family functioning, while the Beck Depression Inventory was used to evaluate the severity of maternal depression. The results suggested that the severity of ASD decreases and improvements in maternal mental health and family functioning were observed in the experimental group, while no significant results were observed in the control group. This study provided preliminary evidence that an eight-week EAA can provide significant improvements in terms of both family and child functioning for children diagnosed with ASD. Further studies in larger samples are needed to investigate these effects.

KEY WORDS autism spectrum disorder, equine-assisted activity, maternal mental health

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EQUINE ASSISTED ACTIVITIES FOR CHILDREN WITH ASD
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Introduction

The presence of restricted, repetitive patterns of behaviour, interests, or activities are key factors in diagnosing Autism Spectrum Disorder (ASD; American Psychiatric Association, 2013). ASD comprises persistent issues with social communication and interaction throughout many situations. Those situations, particularly, can be seen in social reciprocity, non-verbal communicative behaviours used for social interaction, and the ability to develop, maintain, and understand interpersonal relationships.

Animals have been used to increase socialization among patients in mental institutions from as early as the 18th century, and such therapeutic activities have been referred to as animal-assisted intervention (AAI) (Serpell, 2006). Researchers have observed positive treatment outcomes of utilizing AAI in some clinical populations, specifically with children who have conduct attention-deficit hyperactivity disorder (Katcher & Wilkins, 1998) as well as schizophrenia (Barak et al., 2001). AAI has also been applied to children diagnosed with ASD, and its beneficial effects for those children have been observed, such as an increase in social engagement (Esposito et al., 2011). The positive results of such therapies can be related to human-animal interaction theory, which posits that many people seek contact with animals due to their calming nature and ability to act as a non-judgmental source of support and facilitator of social interaction (Dingman, 2008; Kruger & Serpell, 2010).

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Equine-assisted activities (EAA) are specific subgroup activities of AAI, which include therapeutic horseback riding, vaulting, carriage driving and other non-riding activities with animals. Recent studies suggest that children with ASD who participated in EAA experienced significant increases in social interaction, improved sensory processing and decreased severity of the symptoms associated with ASD (Ward et al., 2011; Ward et al., 2013). In Bass et al. (2009), children with ASD who participated in a 12-week therapeutic riding programme experienced improved social functioning. Therapeutic riding programmes are also responsible for increases in sensory-seeking behaviours, social motivation, and focus on tasks (Bass et al., 2009). Similar results were reported in the study of Gabriels et al. (2012), which consisted of 10 weeks of therapeutic riding programmes. Children with ASD who participated in that study had better self-regulation behaviours following the programme. Rothe et al. (2005) found that child-horse interaction causes increases in socialization and self-esteem. Furthermore, equine-assisted therapy was found to be beneficial for behavioural and mental health problems among children with ASD (Schultz et al., 2007).

ASD is usually diagnosed in childhood, and patients with ASD commonly require lifelong support (Seltzer et al., 2004). As such, parents undertaking the responsibility of being the primary caregivers of children with ASD have been found to experience increased stress, health problems, and a greater sense of restriction compared to parents who do not have disabled children (Beresford, 1994; Flynt et al., 1992; Kornblatt & Henrich, 1985; Roach et al., 1999; Seligman & Darling, 1997). Mothers specifically experience a heavy sense of guilt and a decrease in their wellbeing, which can lead to depression. The stressful situations these families face can result in issues within family life and family functioning. Interventions for children may also benefit parents and family functioning.

The number of scientific studies examining the changes caused by the relationship of animals with children with autism and their families is very low. Wright et al. (2015) stated that with the presence of a pet dog living with the family, family functioning increases and the anxiety level of children with autism in the family decreases. The researchers attributed their results to the fact that the presence of an animal at home lowers the level of domestic stress, thereby strengthening family ties and increasing family functioning. They emphasized that activities such as games, dog walking and grooming could be effective in reducing the stress level.

To our knowledge, there was no information about the effectiveness of EAA on maternal mental health and family functioning in the current literature. Thus, in the present study, we aimed to evaluate the effectiveness of EAA in the areas of social functioning, autistic behaviours, family functioning, and clinical severity for children diagnosed with ASD.

Methods

Participants

Twenty-four children (4-12yo, Mage = 6.77±1.3) diagnosed with ASD who appealed to Nevsehir State Hospital for treatment participated in the study. None of the children had genetic syndromes, epilepsy, or mild or moderate intellectual disability. All children had taken special education classes for at least one year and had no previous experience with equine-assisted activities. In addition, none of them used psychotropic drugs. Those 24 children, as well as their mothers, accepted the invitation to participate in the study. The participants were randomly assigned to two groups, experimental group (4 female and 8 male, Mage=6.75±0.7) and control group (3 female and 9 male, Mage=6.7±0.64). Participants from both groups continued their regular treatments and special educations during the eight-week period. The clinicians and educators were blinded to the study. The experimental programme consisted of eight sessions of equine-assisted activities. Parents signed the informed consent form to allow their children to participate in this study. The consent form was in accordance with the Declaration of Helsinki as amended by the World Medical Association Declaration of Helsinki (World Medical Association, 2013) and was approved by the Ethics Committee of Nevşehir Hacı Bektaş Veli University.

Assessments

To test global functioning, the Children's Global Assessment Scale (CGAS; Shaffer et al., 1985) was used. This scale is a widely used measure of overall severity of child disturbance, providing a clinician-rated index of functioning. Scores range from 0 to 100, with higher scores indicating higher levels of functioning and lower scores indicating greater functional impairments.

The McMaster Family Assessment Device (FAD) was used for family functioning. FAD was developed by Epstein, Bolwin, and Bishop (1983). FAD was administered to the parents to evaluate family functioning and to outline the problematic dimensions of family functioning (Epstein et al., 1983). It includes 60 items that are divided into problem-solving, communication, roles, affective responsiveness, affective involvement, behaviour control, and general function areas. Scores for scales range between 1.00 (healthy) and 4.00 (non-healthy). The reliability and validity of the Turkish version of FAD have previously been evaluated by Bulut (1990) with acceptable test-retest reliability of between .62 and .90.

The Social Communication Questionnaire (SCQ) was used to test social functioning. The SCQ is a 40-item parent report that measures behavioural characteristics of autism spectrum disorders, including communication skills and social functioning for children over four years old. The reliability and validity study of the Turkish version was conducted by Avcil et al. (2015).

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The Beck Depression Inventory (BDI) was developed to detect depression in mental healthcare settings and consists of 21 queries. Responses are on a scale of 0 to 3 in reference to the previous fortnight (total score range 0–63) with higher scores indicating greater severity (Beck, 1960). The reliability and validity study of the Turkish version was conducted by Hisli (1988).

Equine-Assisted Activity Procedure

The risks that may be encountered during the sessions, the content of the sessions, and the protocol to be followed were presented to the families of the participants by the informed consent form. An occupational therapist, a physical therapist, a therapeutic riding instructor, a speech and language therapists and a paediatrician were present in all sessions of the eight-week EAA programme. The Professional Association of Therapeutic Horsemanship International guidelines were administered, which means that a trained volunteer was leading the horse and two volunteers walking along either side of the horse (side-walkers) to ensure the rider's safety in all sessions. A certified instructor with specialized training in therapeutic horsemanship chose the horses for each rider, taking into consideration the size and ability of the riders and supervised all sessions.

A one-hour session was implemented for the participants each week, and two participants have attended a session at the same time. Sessions consisted of easy-to-apply and fun activities for the participants, such as grooming and feeding, mounting and dismounting, horsemanship activities, exercises to improve riding skills, mounted games, walking together with the horse, riding. Toys, balls, boxes, circles, cones and such materials were used as exercise materials. The content of the sessions was organized in a way that activities met participant's goals and objectives considering their disabilities. When a participant progressed in skills and or tasks (physical, cognitive, etc.), new ones were presented after an expression of appreciation and encouragement. For unsuccessful attempts, participants were motivated to redo the task. Eye contact between the participant and other people present was encouraged but not forced during the communication.

The sessions included preparation, warm-up, mounting, main session, and finishing. Preparation activities included wearing a security vest and equestrian helmet, preparation of supplementary materials and the field, and taking precautions about environmental safety. Warm-up included performing basic movements on a walking horse in an average of 5-8 minutes. Starting with head rotation to the right and left; horizontal, vertical, circular movements of the arms; forward, backward, downward stretches and reaches, upper body right and left rotations, front and back bending, moving legs sideways and back and forth, pulling up the knees. The participant mounts the horse with specialist support on the mounting platform using a related technique. The main session included the implementation of appropriate physical-mental-sensory exercises for 15-20 minutes. In finishing, movements and behaviours were applied with the retention of the main skills of the session in a game-like situation.

Data Analysis

Three different instruments were used to determine family functioning, communication skills and social functioning, and depression. Prior to the main analyses, parametric test assumptions (normality, skewness and kurtosis) were tested, and it was decided to use two-way mixed-model ANOVA in line with the test results. The group (experimental and control) was treated as a between factor, and the measurement (pre- and post-tests) was treated as a within factor. Please note that the average value of both the Children's Global Assessment Scale and Social Communication Questionnaire was included in the analysis. However, separate statistical analyses were conducted for each subscale of the McMaster Family Assessment Device. The statistical significance level was set as $p < .05$.

Results

Global Functioning

Figure 1 presents the average value of The Children's Global Assessment Scale (CGAS). There is a substantial increase from pre- to post-test in the experimental group, control group scores stayed the same. A 2-way mixed-model ANOVA with measurement (pre- and post-tests) as within-subject factors, and group (experimental and control) as between-subject factors revealed a significant main effect of measurement, $F(1,22)=16.31$, $p=.0005$, $\eta2=.59$. This main effect revealed that CGAS scores significantly increased from pre- ($M=56.41$ and $SD=8.8$) to post-test ($M=58.8$ and $SD=10.8$). Moreover, measurement*group interaction was also found to be significant: $F(1,22)=17.47$, $p=.0004$, $\eta2=.61$. Post-hoc analysis revealed that the scores for the experimental group significantly increased from pre- ($M=57$ and $SD=9.24$) to post-test ($M=61.83$ and $SD=11.47$).

The McMaster Family Assessment Device (FAD)

As stated earlier, FAD has seven subscales, and statistical analyses were conducted separately for each scale. Figure 2 shows the average scores of FAD for each subscale. For the problem-solving subscale, mixed-model ANOVA revealed no main effects for measurement ($p>.05$) and group ($p>.05$) and measurement*group interaction ($p>.05$).

Mixed-model ANOVA for communication subscale revealed only a significant measurement*group interaction, $F(1,22)=13.83$, $p=.001$,$\eta2=.44$. Post-hoc analysis revealed that the scores for the experimental group significantly decreased from pre- ($M=2.5$ and $SD=0.52$) to post-test ($M=2.2$ and $SD=0.59$).

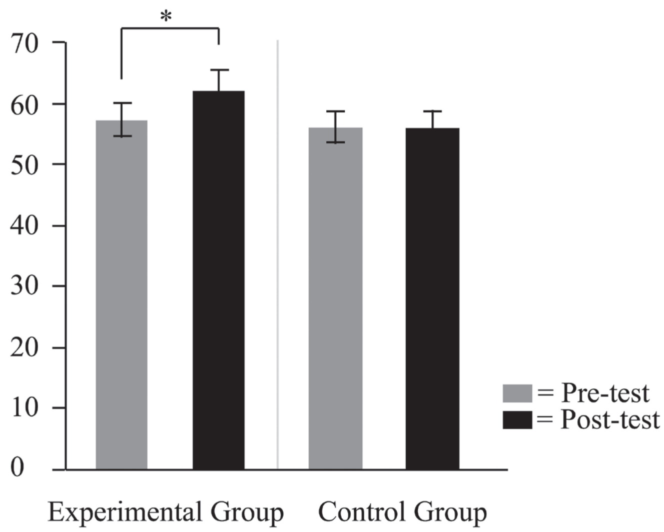

FIGURE 1. The average value of the Children's Global Assessment Scale between experimental and control groups within pre- to post-tests

Statistical analysis for the Roles subscale displayed a significant main effect of measurement, F(1,22)=5.55, p=.02,η2=.11. This main effect revealed that scores significantly decreased from pre- (M=2.3 and SD=0.54) to post-test (M=2.14 and SD=0.53). Moreover, measurement*group interaction was also found to be significant, F(1,22)=16.73, p=.0005,η2=.60. Post-hoc analysis revealed that the scores for the experimental group significantly decreased from pre- (M=2.31 and SD=0.59) to post-test (M=1.88 and SD=0.38). There was no change in the control group's scores.

For the Affective Responsiveness subscale, statistical analysis revealed no main effects for measurement (p>.05) and group (p>.05) and measurement*group interaction (p>.05).

Statistical analysis for the Affective Involvement subscale showed only a significant measurement*group interaction, F(1,22)=6.97, p=.01, η2=.12. Post-hoc analysis revealed that the scores for the experimental group significantly decreased from pre- (M=2.38 and SD=0.58) to post-test (M=1.93 and SD=0.59). Moreover, the experimental group post-test score (M=1.93 and SD=0.59) was significantly lower than the control group post-test score (M=2.42 and SD=0.56).

Mixed-model ANOVA for the Behavioural Control subscale revealed only a significant measurement*group interaction, F(1,22)=6.41, p=.01, η2=.11. Post-hoc analysis revealed that the scores for the experimental group significantly decreased from pre- (M=2.23 and SD=0.55) to post-test (M=1.93 and SD=0.38). Moreover, the experimental group post-test score (M=1.93 and SD=0.38) was significantly lower than the control group post-test score (M=2.35 and SD=0.47).

For the General Functions subscale, statistical analysis revealed no main effects for measurement (p>.05) and group (p>.05) and measurement*group interaction (p>.05).

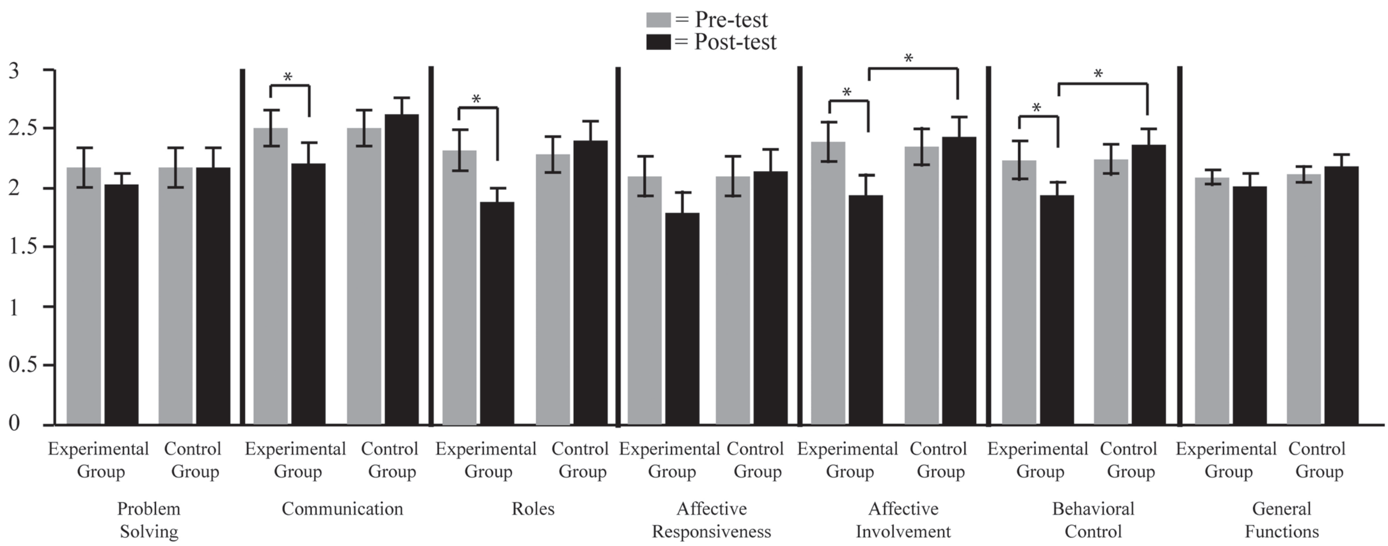

FIGURE 2. The average scores of the McMaster Family Assessment Device between experimental and control groups within pre- to post-tests among the subscales.

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Overall, out of seven subscales of FAD, a significant decrease was found among four different subscales from pre- to post-test for the experimental group.

Social Communication Questionnaire (SCQ)

Figure 3 shows the average scores of SCQ. The statistical analysis for SCQ revealed a significant main effect of measurement, $F(1,22)=12.20$, $p=.002$, $\eta 2=.41$. This main effect revealed that scores significantly decreased from pre- ($M=20.16$ and $SD=4.02$) to post-test ($M=19.08$ and $SD=3.97$). Moreover, measurement*group interaction was also found to be significant, $F(1,22)=18.23$, $p=.0003$, $\eta 2=.62$. Post-hoc analysis revealed that the scores for the experimental group significantly decreased from pre- ($M=19.92$ and $SD=4.12$) to post-test ($M=18.25$ and $SD=3.70$). There was no change in the control group's scores.

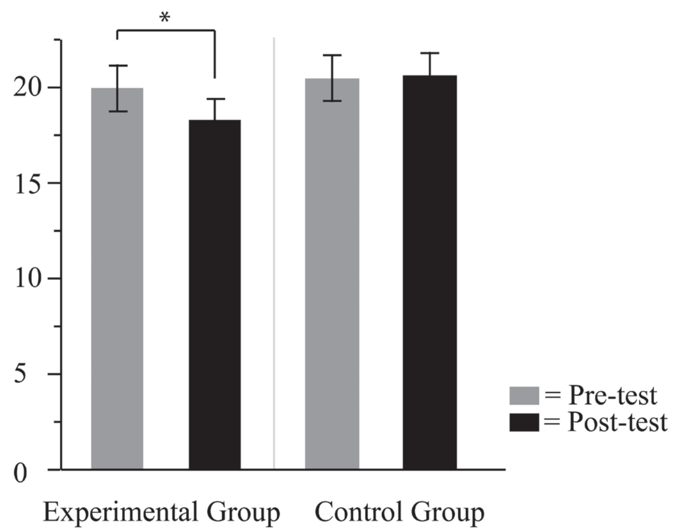

FIGURE 3. The Average value of Social Communication Questionnaire between experimental and control groups within pre- to post-tests.

Beck Depression Inventory (BDI)

Figure 4 shows the average scores of BDI. Similar to SCQ, the statistical analysis for BDI displayed a significant main effect of measurement, $F(1,22)=22.06$, $p=.0001$, $\eta 2=.68$. This main effect revealed that scores significantly decreased from pre- ($M=18.37$ and $SD=5.65$) to post-test ($M=17$ and $SD=5.06$). Moreover, measurement*group interaction was also found to be significant, $F(1,22)=8.93$, $p=.006$, $\eta 2=.15$. Post-hoc analysis revealed that the scores for the experimental group significantly decreased from pre- ($M=18.5$ and $SD=6.31$) to post-test ($M=16.25$ and $SD=5.46$). There was no change in the control group's scores.

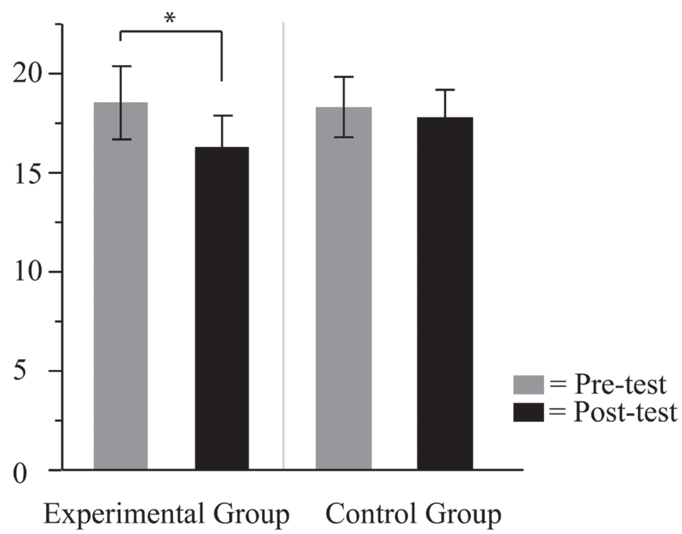

FIGURE 4. The average value of Beck Depression Inventory between experimental and control groups within pre- to post-tests.

Discussion

The current study, to our knowledge, was the first to investigate the effects of EAA on family functioning and maternal depression. This study provided preliminary evidence that an eight-week EAA with children diagnosed with ASD displayed significant improvements in terms of both family and child functioning. The results of the present study showed a decrease in the severity of ASD with the Children's Global Assessment Scale and Social Communication Questionnaire, which is consistent with the current literature (Bass et al., 2009; Lanning et al., 2014). Although Jenkins and DiGennaro Reed (2013) reported no influence of EAA on the behaviour of children with ASD, others found substantial decreases in ASD severity after subjects experienced EAA and no decreases in subjects in control groups (Bass et al., 2009; Kern et al., 2011). In fact, with such a range of measures, it is not surprising to see inconsistent results of research on the influence of EAA, which could also be related to the fact that the participants' different levels of skills and functioning and the content of the lessons could have been different. Thus, the result for the effect of therapeutic riding for children diagnosed with ASD in our study is consistent with the current literature.

Therapeutic riding sessions include the interaction between the horse and child; during this interaction, children can develop positive social behaviours and improve self-confidence, self-regulation, and self-respect. In particular, the feeling of riding a horse by themselves can positively improve the self-confidence of children diagnosed with ASD. As the children accomplish the riding task by themselves, they become motivated. For example, when a non-verbal child is asked to communicate with the horse by imitating the word "go" to initiate movement in riding, the horse starts walking, even if the vocal attempt is approximate. This may continue for similar trials, such as "Oo" or "Gg" to initiate movement. This procedure may increase with the self-confidence of the child's behaviours (Grundtvig project, 2014). All of those attempts can reduce ASD severity, which was found in the current study.

Improvements in the mental health of children also affect maternal mental health and family functioning. The results for these factors showed positive improvements in many areas, specifically the depression levels of mothers, from the pre- to post-test for the experimental group. Similar to depression levels, family functions were also improved in the experimental group in the current study. Among the seven subscales of FAD, roles, communication, behavioural control, and affective involvement subscales were found to be enhanced in the mothers who were in the experimental group.

Studies about the general population suggest that family cohesion and adaptability are positively associated with parent wellbeing (Uruk et al., 2007; Vandeleur et al., 2009). Stressors that occur with taking care of a family member with ASD or any developmental disorder can have a significant negative effect on families, and in some cases, cause crises (Weiss & Lunsky, 2011), which may mix the roles of members in the family, and one important result of our study is the effectiveness of EAA on the roles of family functioning. The communication of families is increased after EAA, which is related to the social involvement of children and their parents. This may also be related to decreases in maternal depression.

In Weiss and Lunsky's (2011) study, the Brief Family Distress Scale (BFDS) is used to quantify levels of stress and functioning in families that include children with ASD; the BFDS scores correlate positively with problematic coping mechanisms and outcomes and correlate negatively with effective coping mechanisms and positive adjustment. Problematic coping strategies also result in depression; thus, decreasing maternal depression and modulating family functioning may provide suitable effective involvement and behaviour control for mothers. Therefore, family functioning and maternal wellbeing must be targeted in the treatment of the children with ASD. Less is known about which treatments affect family functioning and parental wellbeing positively. However, the present study investigated the effectiveness of EAA on maternal wellbeing and family functioning and found the beneficial effect of EAA on both mothers and their children who are diagnosed with ASD. There was no interaction between horses and families during the activity stage of the study. Therefore, it is possible to say that the change observed in the family functioning occurred due to the positive change in children with autism. As stated in the study by Wright, we attribute positive changes in family functions to the reflection of the changes that occur as a result of the connection of children with autism with animals with high interaction.

In conclusion, the current study found the positive effect of therapeutic riding on children who are diagnosed with ASD and, in turn, this also led to improvements in maternal mental health and family functioning. The main aim of the treatments is to create respectful relationships that teach children diagnosed with ASD appropriate social skills, have enjoyable cognitive development and increase important personality traits like self-confidence and self-esteem.

The generalization of the current study is limited by the small sample size. However, it is still conceivable that the sample size of this study is similar to the ones in the literature. Even though the McMaster Family Assessment Device, Social Communication Questionnaire, and Beck Depression Inventory were filled out by mothers and this may introduce bias into the results for those measurements, it has also previously been stated that parental evaluation is an effective method of evaluation and has been widely used in research in this area (Limbers et al., 2009). One last limitation is the duration of EAA, which was limited to eight weeks due to contextual factors, in our case.

Increasing the number of participants for future studies would improve the generalizability of the study. The duration for EAA could be lengthened in future studies; such lengthening might display additional positive results. By studying this factor, we can observe or decide the optimal time for the EAA for this treatment group. Future studies should focus on whether EAA can also be beneficial for motor abilities. In the treatment of EAA, different therapeutic centres could be used to determine whether greater variation motivates and socializes both the children and parents. We would also suggest that further studies be conducted to determine whether all proven ASD therapies for children also have positive effects on maternal wellbeing and family

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functioning or whether EAA is a unique therapy in terms of these additional benefits. Anecdotal verbal reports from all parents whose children had undergone EAA indicated positive improvements in their child's behaviours and socialization, and those parents eagerly wanted to have their children continue to engage in EAA. Thus, governments should support the existing therapeutic horseback riding centres.

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All procedures performed in the present study were in accordance with the ethical standards of Nevsehir Haci Bektas Veli University Ethics Committee and with the 1964 Helsinki declaration and its later amendments.

References
American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders (DSM-5®)*. American Psychiatric Pub.

Avcil, S., Baykara, B., Baydur, H., Münir, K. M., & Emiroğlu, N. İ. (2015). The Validity and Reliability of The Social Communication Questionnaire-Turkish Form in Autistics Aged 4-18 Years. *Türk psikiyatri dergisi= Turkish journal of psychiatry*, *26*(1), 56.

Barak, Y., Savorai, O., Mavashev, S., & Beni, A. (2001). Animal-assisted therapy for elderly schizophrenic patients: A one-year controlled trial. *The American journal of geriatric psychiatry*, *9*(4), 439-442.

Bass, M. M., Duchowny, C. A., & Llabre, M. M. (2009). The effect of therapeutic horseback riding on social functioning in children with autism. *Journal of autism and developmental disorders*, *39*(9), 1261-1267. doi: 10.1007/s10803-009-0734-3

Beck, A. T., Ward, C., & Mendelson, M. (1961). Beck depression inventory (BDI). *Archives of general psychiatry*, *4*(6), 561-571.

Beresford, B. A. (1994). Resources and strategies: How parents cope with the care of a disabled child. *Journal of Child Psychology and Psychiatry*, *35*(1), 171-209.

Bulut, I. (1990). Aile değerlendirme ölçeği el kitabı. *Ankara: Özgüzeliş Matbaası*, 6-8.

Dingman, A. (2008). Hoof prints: Equine therapy for autistic children. *Encounter*, *21*(4), 11-13.

Epstein, N. B., Baldwin, L. M., & Bishop, D. S. (1983). The McMaster family assessment device*. *Journal of marital and family therapy*, *9*(2), 171-180.

Esposito, L., McCardle, P., Maholmes, V., McCune, S., & Griffin, J. A. (2011). Introduction. In P. McCardle, S. McCune, J. A. Griffin, L. Esposito, & L. S. Freund (Eds.), *Animals in our lives: Human– animal interaction in family, community, and therapeutic settings* (pp. 1–5). Baltimore, MD: Brookes Publishing Co.

Flynt, S. W., Wood, T. A., & Scott, R. L. (1992). Social support of mothers of children with mental retardation. *Mental retardation*, *30*(4), 233.

Gabriels, R. L., Agnew, J. A., Holt, K. D., Shoffner, A., Zhaoxing, P., Ruzzano, S., et al. (2012). Pilot study measuring the effects of therapeutic horseback riding on school-age children and adolescents with autism spectrum disorders. *Research in Autism Spectrum Disorders*, 6(2), 578–588.

Grundtvig Project '*Taught me How to Walk*' Developed between Italy, Greece, Turkey and Croatia, Copyprint S.n.c.-Centro Copia Stampa, July 2014.

Hisli-Sahin, N. (1988). Beck Depresyon Envanteri'nin gecerligi uzerine bir calisma. *Türk Psikoloji Dergisi*, *6*(22), 118-126.

Jenkins, S. R. & DiGennaro Reed, F. D. 2013. An experimental analysis of the effects of therapeutic horseback riding on the behavior of children with autism. *Research in Autism Spectrum Disorders* 7(6), 721–740.

Katcher, A. H., & Wilkins, G. G. (1998). Animal-assisted therapy in the treatment of disruptive behavior disorder in childhood. In A. Lundberg (Ed.), *The environment and mental health* (pp. 193–204). Mahwah, NJ: Lawrence Erlbaum Associates, Inc.

Kern, J. K., Fletcher, C. L., Garver, C. R., Mehta, J. A., Grannemann, B. D., Knox, K. R., et al. (2011). Prospective trial of equine assisted activities in autism spectrum disorder. *Alternative Therapies*, 17(3), 14–20.

Kornblatt, E. S., & Heinrich, J. (1985). Needs and coping abilities in families of children with developmental disabilities. *Mental Retardation*, *23*(1), 13.

Kruger, K. A., & Serpell, J. A. (2010). Animal-assisted interventions in mental health: Definitions and theoretical foundations. In A. H. Fine (Ed.), *Handbook on animal-assisted therapy: Theoretical foundations and guidelines for practice* (3rd ed., pp. 33–48). San Diego: Academic Press.

Lanning, B. A., Baier, M. E. M., Ivey-Hatz, J., Krenek, N., & Tubbs, J. D. (2014). Effects of equine assisted activities on autism spectrum disorder. *Journal of autism and developmental disorders*, 44(8), 1897-1907. doi: 10.1007/s10803-014-2062-5

Limbers, C. A., Heffer, R. W., & Varni, J. W. (2009). Health-related quality of life and cognitive functioning from the perspective of parents of school-aged children with Asperger's Syndrome utilizing the PedsQLTM. *Journal of Autism Developmental Disorders*, 39, 1529–1541.

Roach, M. A., Orsmond, G. I., & Barratt, M. S. (1999). Mothers and fathers of children with Down syndrome: Parental stress and involvement in childcare.*American Journal on Mental Retardation*, *104*(5), 422-436.

Rothe, E. Q., Vega, B. J., Torres, R. M., Soler, S. M., & Pazos, R. M. (2005). From kids and horses: Equine facilitated psychotherapy for children. *International Journal of Clinical and Health Psychology*, 5(2), 373–383.

Schultz, P. N., Remick-Barlow, G. A., & Robbins, L. (2007). Equine assisted psychotherapy: A mental health promotion/intervention modality for children who have experienced intra-family violence. *Health and*

Social Care in the Community, 15(3), 265–271.

Seligman, M., & Darling, R. B. (1997). *Ordinary families, special children: A systems approach to childhood disability.* New York: The Guilford Press

Seltzer, M. M., Shattuck, P., Abbeduto, L., & Greenberg, J. S. (2004). Trajectory of development in adolescents and adults with autism. *Mental retardation and developmental disabilities research reviews*, 10(4), 234-247.

Serpell, J. A. (2006). Animal-assisted interventions in historical perspective. In A. H. Fine (Ed.), *Handbook on animal-assisted therapy: Theoretical foundations and guidelines for practice* (2nd ed., pp. 3–20). San Diego, CA: Academic Press.

Shaffer, D., Gould, M. S., Brasic, J., Ambrosini, P., Fisher, P., Bird, H., & Aluwahlia, S. (1985). A children's global assessment scale (CGAS) (for children 4 to 16 years of age). *Psychopharmacology Bulletin*, 21(4), 747–748.

Uruk, A. Ç., Sayger, T. V., & Cogdal, P. A. (2007). Examining the influence of family cohesion and adaptability on trauma symptoms and psychological wellbeing. *Journal of College Student Psychotherapy*, *22*(2), 51-63.

Vandeleur, C. L., Jeanpretre, N., Perrez, M., & Schoebi, D. (2009). Cohesion, Satisfaction With Family Bonds, and Emotional Well-Being in Families With Adolescents. *Journal of Marriage and Family*, *71*(5), 1205-1219.

Ward, S. C., Whalon, K., Rusnak, K., Wendell, K., & Paschall, N. (2013). The association between therapeutic horseback riding and the social communication and sensory reactions of children with autism. *Journal of autism and developmental disorders,* 43(9), 2190-2198. doi: 10.1007/s10803-013-1773-3.

Ward, S. C., Whalon, K., Stiles, K., & Smith, A. (2011). The effects of therapeutic horseback riding on children with autism. San Francisco, CA: Poster presented at the annual meeting of the National Association of School Psychologists.

Weiss, J. A., & Lunsky, Y. (2011). The brief family distress scale: A measure of crisis in caregivers of individuals with autism spectrum disorders. *Journal of Child and Family Studies*, 20(4), 521–528.

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REVIEW PAPER

Psychological Aspect of Rehabilitation and Return to Sport Following Lower Limb Injuries

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ABSTRACT In addition to an athlete's physical abilities, his or her mental state is also vital for optimal recovery and a successful return to sport after an injury. The purpose of the present review was to determine which psychological factors affect the success of rehabilitation and return to sport following the most frequent musculotendinous thigh injuries (hamstrings, hip adductors, knee extensors), and to present the main psychological screening tools and interventions that can aid the athlete's rehabilitation and return to sport. A systematic review of the literature did not reveal any relevant results related to those injuries; therefore, the search was expanded to whole lower limb injuries, which showed that several different psychological factors could have a significant impact on an athlete's rehabilitation and decision to return to sport. It can be presumed that these factors can similarly affect the post-injury process for thigh injuries, which should be considered when planning the rehabilitation programme. Systematically implementing psychological screening and psychological interventions (if needed) into the already established rehabilitation protocols would be reasonable for optimizing an athlete's recovery and for helping with the decision to return to sport.

KEY WORDS psychology, leg injuries, rehabilitation, return to sport

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Introduction

For those working in the field of sports injuries prevention and rehabilitation, knowing and understanding the factors that can affect the outcome of rehabilitation and the success of the athlete's return to sport after a sport injury is essential. Only by considering all the factors can an athlete optimally prepare (physically and mentally) for an effective return to the competition while minimizing the risks of re-injury. This is particularly important, since previous injury is one of the most critical risk factors (i.e., the most reliable predictor) for the occurrence of injury, especially amongst the most common musculotendinous injuries (Beijsterveldt, Port, Vereijken, & Backx, 2012; Mosler et al., 2018).

There is a significant number of research and evidence-based protocols for successful rehabilitation after sports injuries in terms of the recovered functionality and physical performance of the injured body part/joint. Nevertheless, even completely recovered physical abilities (achieving all the recommended milestones of the rehabilitation protocol) do not guarantee the athlete a successful return to sport. Ardern, Webster, Taylor, and Feller (2011) showed that there was a difference between the number of successful rehabilitations and the number of successful returns to sport. Part of that difference can be explained by various factors, such as injury in addition to the physical and functional limitations it causes, that can also affect the psychological state of an athlete. Furthermore, research shows several different psychological factors that can negatively affect the process of sport rehabilitation, its outcome and even the decision about continuing with sports career or not (Booth-Kewley et al., 2014; Kvist, Ek, Sporrstedt, & Good, 2005). These facts raise the question of whether the current criteria for successful rehabilitation are appropriately defined, as they often focus only on the physical fitness of patients, while their mental state is, to a great extent, neglected.

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Our review revealed a considerable lack of research about the psychological factors that can affect the successful outcome of rehabilitation and return to sport following the most common musculotendinous thigh injuries. These injuries represent a substantial problem in some sports, as they account for the majority of all sports injuries. Ekstrand, Hägglund, and Waldén (2011) showed that in soccer 92% of all injuries belong to the following muscle groups: 37% hamstrings, 23% hip adductors, 19% knee extensors, and 13% calf muscles. The impact of psychological factors on the recovery and return to sport after these injuries can only be deduced from a much more researched area of injuries: the knee joint, specifically the anterior cruciate ligament (ACL) injuries. Thus, the purposes of this paper are (based on a systematic literature review): (i) to verify which are the most important psychological factors that can affect the outcome of rehabilitation and the successful return to sport following lower limb sport injuries; (ii) to determine whether these psychological factors can similarly affect an athlete with a musculotendinous thigh injury during rehabilitation and the return to sport; (iii) to present the primary screening tools and interventions that can psychologically help an athlete and rehabilitation/prevention specialist. Identifying and monitoring psychological factors could help optimize preventative and rehabilitative programmes for these injuries and reduce the number of failed returns to sports. Therefore, an athlete's mental state after a sport injury should be just as carefully monitored and managed (if needed) as his/her physical abilities.

Methods

Search strategy

The original idea was to systematically review the literature about psychological factors that can affect athlete's rehabilitation or decision making about the return to sport specifically after the most frequent lower limb injuries in sports, such as American football, soccer and track and field, which are injuries to the hamstrings, knee extensors, and hip adductors. Given that initial search strings revealed no relevant results, suggesting a lack of research on this topic, we expanded the review to the whole lower limb injuries.

The PubMed database was searched in a systematic way for relevant articles published before October 2019. Search terms were divided into three concepts: Concept 1 included injury areas, Concept 2 included injury expressions, and Concept 3 included psychological aspects. Within each concept, the terms were grouped with the OR operator, and all three concepts were then combined with the AND operator into the following search string: (adductor OR hamstring OR groin OR rectus femoris OR quadriceps OR lower extremity OR ankle OR hip OR knee) AND (injury OR re-injury OR sport injury OR strain OR avulsion OR rupture) AND (psychology OR fear OR avoidance OR motivation OR anxiety OR psychological rehabilitation).

This search resulted in 2713 articles, which were then filtered by species (humans) and language (English), which resulted in 2340 articles. Each article was reviewed for inclusion with one of the following criteria: reports about the effect of psychological factors on rehabilitation outcome or return to sport after an injury of the lower extremity, reports about the psychological state of a patient/athlete after an injury of the lower extremity, reports about the impact of psychological interventions on rehabilitation outcome or patient's psychological state. Twenty-seven articles were eligible and thus included in this review.

Results

Psychological factors related to rehabilitation and return to sport after an ACL injury

Our review revealed a complete lack of research about the possible impact of psychological factors on an athlete's success of rehabilitation or return to sport after the injuries of hamstrings, knee extensors or hip adductors. In addition, the majority of the research about the psychological factors and their effects on rehabilitation and return to sport was done on patients/athletes with ACL tears (22 articles of 27 selected and included in this review). Most rehabilitation protocols after the reconstruction of the ACL (RACL) monitor patient's progress based on their injured knee ROM, degree of pain, overall knee functionality and strength of m. quadriceps. Return to sport is recommended upon reaching 90% lateral symmetry in knee extension strength and one-legged hop test (Grindem, Snyder-Mackler, Moksnes, Engebretsen, & Risberg, 2016). It turns out that even when these standards are accomplished, the successful return of the athlete to sport does not always happen. Ardern et al. (2011) concluded that as much as 90% of patients after the RACL regain normal knee functionality (measured as a single-limb hop for distance, isokinetic muscle strength or anterior knee laxity), but only half of the athletes return to the competitive sport. Psychological factors, such as fear of re-injury (Kvist et al., 2005; Lentz et al., 2015; Nwachukwu et al., 2019; Te Wierike, Van Der Sluis, Van Den Akker-Scheek, Elferink-Gemser, & Visscher, 2013), anxiety (Kosy et al., 2019), self-efficacy (the individual's judgement about his/her ability to perform a particular task) (Baez, Hoch, & Hoch, 2019; Beischer et al., 2019; Te Wierike et al., 2013) motivation (Sonesson, Kvist, Ardern, Österberg, & Silbernagel, 2017), and increased rate of kinesiophobia (fear of movement) (Czuppon et al. 2014) may be the cause of such significant reduction of successful returns to sport after the RACL. Kinesiophobia and fear of re-injury are linked to reduced muscle endurance, muscle activation, dynamic knee stability, limited knee range of motion, self-reported function, and altered muscle recruitment strategies (Hsu, Meierbachtol, George, & Chmielewski, 2017). Ardern, Taylor, Feller, Whitehead, and Webster (2013) and Te Wierike et al. (2013) reported a significant effect of internal health locus of control (the degree to which individuals perceive their ability to control life events). These authors assumed that the higher rate of patients' internal health locus of control enables better rehabilitation outcomes after the RACL, as it determines patients' self-esteem and their belief in themselves and

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in the positive outcome of rehabilitation, which could be a necessity for achieving good adherence to the rehabilitation programmes.

Everhart, Best, and Flanigan (2015) focused on predictive psychological factors for the recovery outcomes after RACL. They found that the patient's level of self-esteem, optimism, self-motivation, stress, social support, and self-identity as an athlete can predict the success of rehabilitation after RACL. They were able to connect these factors to the patient's level of pain and functionality of the injured knee, which can affect the successful return to sport. Furthermore, Masten et al. (2014) showed that the success of rehabilitation could be predicted from changes in certain psychosocial variables: a decrease in anxiety and an increase in susceptibility, self-efficacy and coping with pain. The decision to return to sport may also be influenced by the results of self-evaluation questionnaires on the functionality of the knee joint after the RACL. When using these, therapists must also consider the athlete's psychological state, which can negatively affect the results of the questionnaire. Patients diagnosed with severe depressive disorder reported significantly lower functionality after having equally successful RACL compared to psychologically healthy subjects (Garcia et al., 2016). Furthermore, athletes who did not return to sport had lower self-reported scores of the injured knee functionality after the RACL compared to the athletes who had a successful return to sport, even though both groups had similar (objectively measured) physical performance scores (star excursion balance test, single-legged hop tests, isokinetic knee flexors/extensors strength, step down endurance test) (Werner et al., 2018).

A qualitative study (Burland et al., 2018) with semi-structured interviews of 12 injured athletes revealed the following psychological factors (in addition to the fear of re-injury) that may influence the decision about returning to sports after the RACL: hesitation and lack of self-confidence to continue with a sport career, changes in (life) priorities, athletic identity, as well as expectations and assumptions about the rehabilitation process and its outcome. The participants had distorted beliefs about rehabilitation and were mentally unprepared, meaning that they did not know the proper psychological ways to manage the situation after the injury. Furthermore, the authors identified increased awareness of the injured knee as a psychological factor that can also have an adverse impact on the return to sport, since it is closely linked to the fear of re-injury and movement in general. This factor can be intensified when using various joint braces or kinesiotape (often used during rehabilitation), as it can also serve as a constant physical reminder of the injury and thus further increase the self-awareness of the affected joint (Burland et al., 2018). An additional factor that can affect the athlete's psychological state is the post-injury social support system (moral support and encouragement from teammates and coaches, and a good relationship with the therapist). It can have a significant positive or negative impact on rehabilitation outcome and return to sports. Burland et al. (2018) logically grouped the identified factors into the dynamic biopsychosocial model, developed by Wiese-Bjornstal, Smith, Shaffer, and Morrey (1998), which includes four main components:

- cognition (in addition to the athlete's post-injury thinking, it also includes various psychological factors that can influence the course and outcome of rehabilitation and the decision about returning to sport);
- affect (refers to the influence of emotions and different moods that surround an athlete after an injury);
- behaviour (consists of behaviours that involve the athlete's specific activities and efforts after an injury, which are highly influenced by cognition and affect);
- outcome (refers to the athlete's rehabilitation results and, most importantly, his/her decision to return to competition or to terminate his/her career).

These four components are interrelated and dynamic regarding the patient's response to the sport injury and rehabilitation process.

Psychological factors affecting rehabilitation of other lower limb injuries

Psychological factors have also been addressed and proven to be critical during the recovery from ankle injuries. Briet et al. (2016) reported a significant association between self-efficacy and the results of the Olerud-Molander Ankle Score questionnaire designed to assess the limitations associated with an ankle injury. Patients with lower levels of self-efficacy have been found to experience higher levels of pain and to have more physical limitations and more severe injury symptoms. In contrast, the severity of the injury or the degree of ankle sprain had no correlation with the results of the Score. Moreover, several studies have also confirmed a higher level of fear of re-injury and kinesiophobia, both in university athletes with a history of an ankle injury (Houston, Hoch, & Hoch, 2017) and in athletes with chronic ankle instability (Houston, Van Lunen, & Hoch, 2014).

Booth-Kewley et al. (2014) reported recovery expectations as the most significant predictive factor in the success of rehabilitation after musculoskeletal injury (knee, back or shoulder injuries) in soldiers. Individuals with high expectations were five times more likely to recover successfully than individuals with low expectations. The authors state different possible reasons for this: high expectations may be associated with less negative emotions about the injury and greater motivation for the patient to participate consistently in the rehabilitation process; it may also be related to the patient's physiological response, which can directly reduce pain and thus have a positive effect on the success of the recovery. In contrast, negative psychological factors, such as catastrophic thinking, appear to be strongly associated with greater pain intensity and disability after musculoskeletal trauma (Vranceanu et al., 2014).

Discussion

Several psychological factors can affect an athlete's rehabilitation process and its outcome, as well as the success of returning to sports after a sport injury, particularly after RACL and ankle injuries. It can be assumed that the psychological factors affecting the return to sport after knee and ankle injuries could similarly affect the return to sport following the most frequent musculotendinous thigh injuries, the latter being the initial target of this review and the current and near-future research focus of its authors. These injuries can be divided according to severity into three grades. The first-grade injury is characterized by mild muscle strain, a minor decline in muscle strength, and required a few days of recovery. The second-grade injury is characterized by partial muscle tear, a greater decline in muscle strength and recovery is prolonged to several weeks. The third-grade injury is characterized by complete or near-complete tearing of muscle fibres, the recovery time can be extended up to six months, and surgery is required/preferred in most cases. Such thigh injuries are most comparable with the ACL injuries in terms of severity, need for surgery and time of absence from the competition. Given these similarities, the impact of psychological factors on the success of rehabilitation and return to sports could also be comparable. In the case of the first- or second-grade injuries, rehabilitation time is significantly shorter, which may also reduce the impact of psychological factors on return to sport. However, athletes with previous hamstring injuries have a high chance of injury recurrence, depending on the sport: 16 % for soccer (Ekstrand, Hägglund, & Waldén, 2011), 23% for rugby (Brooks, Fuller, Kemp, & Reddin, 2005) and Australian football (Orchard, Seward, & Orchard, 2013), and 3 % for American football (Feeley et al., 2008). Each re-injury could further impair the athlete's mental state and influence the decision about returning to the sport.

Given the repeatedly proven impact of different psychological factors on the athlete's recovery from an injury or return to sport, it would be reasonable to include additional measures in rehabilitation programmes. Consideration, assessment and monitoring of psychological factors often seem underestimated and underused in clinical practice, despite numerous studies indicating the significant impact of these factors on the successful return to sport. Merely monitoring the main psychological factors through a conversation or appropriate questionnaires would give a clearer picture of the athlete's psychological condition and help identify potential complications in returning to sport. Many established questionnaires can discover different psychological factors. To monitor the presence of kinesiophobia, the Tampa Scale questionnaire can be used (Miller, Kori, & Todd, 1991). The Fear-Avoidance Beliefs Questionnaire is used to measure a patient's fear of pain and their avoidance of physical activity. The emotional response to pain can be evaluated by the Pain Catastrophizing Scale, which relates to the patient's excessive thinking about the importance of their pain (Sullivan, Bishop, & Pivik, 1995). There is a valid Knee Self-Efficacy Scale to evaluate the self-efficacy of the (injured) knee (Thomeé et al., 2006). The ACL-Return to Sport after Injury Scale is used to assess psychological readiness to return to sport by evaluating patient's self-motivation and self-confidence after the RACL. Webster, McPherson, Hewett and Feller (2019) showed that psychological readiness is significantly associated with successful return to sport. The psychological aspect of an athletic identity can also be evaluated by the Athletic Identity Measurement Scale. The results of at least some of the mentioned questionnaires should be more systematically included in rehabilitation protocols and their guidelines/norms for the athlete's optimal return to sport.

The implementation of appropriate psychological interventions into the standard rehabilitation protocols would not only positively affect the return to sport success but could even speed up the process itself and/or improve the functional/physical performance results of an athlete. Rehabilitation programmes that include positive self-talk and goal setting are associated with a greater degree of a patient's compliance than the rehabilitation programmes (Everhart et al., 2015) that can facilitate an athlete's return to sport. Moreover, Cupal and Brewer (2001) found a significant positive effect of guided visualization and relaxation (in addition to the standard rehabilitation) on the knee extensors strength, fear of re-injury and pain level after the RACL. Furthermore, intervention with additional education on surgery and planned recovery can positively influence a rehabilitation process after the RACL. By providing instructional video about the rehabilitation programme to patients before the surgery and in the second and sixth week after the surgery, the researchers were able to significantly reduce patients' perception of the anticipated pain, improve their self-efficacy and even the functionality of the injured knee joint (Maddison, Prapavessis, & Clatworthy, 2006). That kind of intervention could also help with patient's uncertainty about their rehabilitation progress, which can also have a negative effect (DiSanti et al., 2018). Te Wierike et al. (2013) concluded that psychosocial interventions such as guided therapies (to increase relaxation and self-efficacy), visualizations and additional education of patients about the course of rehabilitation helped to improve the overall rehabilitation outcome after RACL.

In addition to psychological measures, various knee braces or kinesiotaping may help reduce kinesiophobia in individuals after RACL (Harput, Ulusoy, Ozer, Baltaci, & Richards, 2016). However, caution should be exercised, since these or similar rehabilitation tools/aids can also serve as a constant physical reminder of the injury and thus increase patient's self-awareness of the injured area, which can adversely affect the success of rehabilitation (Burland et al., 2018).

Conclusion

Our review of the scientific literature revealed a complete lack of research about the possible impact of psychological factors on the success of athlete's rehabilitation and return to sports following musculotendinous

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thigh injuries of the hamstrings, hip adductors or knee extensors. The review additionally revealed that most of the research was done on patients who had RACL. These studies showed several different psychological factors that can significantly affect the outcome of post-injury rehabilitation and an athlete's decision to return to sport. The three most commonly mentioned are fear of injury, self-efficacy, and kinesiophobia.

The same psychological factors could have similar effects in cases of (severe) musculotendinous thigh injuries. Thus, for a more comprehensive and optimal post-injury recovery, it would be reasonable to systematically implement, to the already established rehabilitation protocols, the psychological monitoring of an athlete by using various appropriate questionnaires or interviews. Furthermore, different psychosocial interventions have been shown to improve the athlete's psychological state, which can positively impact the rehabilitation and decision to return to sport. However, before using these tools in clinical practice, methodologically appropriate translation and validation of translations into other languages are required for patients who are not fluent in English.

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References

Ardern, C. L., Taylor, N. F., Feller, J. A., Whitehead, T. S., & Webster, K. E. (2013). Psychological responses matter in returning to preinjury level of sport after anterior cruciate ligament reconstruction surgery. *American Journal of Sports Medicine*, *41*(7), 1549–1558. doi: 10.1177/0363546513489284

Ardern, C. L., Webster, K. E., Taylor, N. F., & Feller, J. A. (2011). Return to sport following anterior cruciate ligament reconstruction surgery: A systematic review and meta-analysis of the state of play. *British Journal of Sports Medicine*, *45*(7), 596–606. doi: 10.1136/bjsm.2010.076364

Baez, S. E., Hoch, M. C., & Hoch, J. M. (2019). Psychological factors are associated with return to pre-injury levels of sport and physical activity after ACL reconstruction. *Knee Surgery, Sports Traumatology, Arthroscopy*. (2019). doi: 10.1007/s00167-019-05696-9

Beijsterveldt, A. M. C. Van, Port, I. G. L. Van De, Vereijken, A. J., & Backx, F. J. G. (2012). *Risk Factors for Hamstring Injuries in Male Soccer Players:* 1–10. doi: 10.1111/j.1600-0838.2012.01487.

Booth-Kewley, S., Schmied, E. A., Highfill-McRoy, R. M., Sander, T. C., Blivin, S. J., & Garland, C. F. (2014). A prospective study of factors affecting recovery from musculoskeletal injuries. *Journal of Occupational Rehabilitation*, *24*(2), 287–296. doi: 10.1007/s10926-013-9456-7

Briet, J. P., Houwert, R. M., Hageman, M. G. J. S., Hietbrink, F., Ring, D. C., & Verleisdonk, E. J. J. M. (2016). Factors associated with pain intensity and physical limitations after lateral ankle sprains. *Injury*, *47*(11), 2565–2569. doi: 10.1016/j.injury.2016.09.016

Brooks, J. H. M., Fuller, C. W., Kemp, S. P. T., & Reddin, D. B. (2005). Epidemiology of injuries in English professional rugby union: Part 1 match injuries. *British Journal of Sports Medicine*, *39*(10), 757–766. doi: 10.1136/bjsm.2005.018135

Burland, J. P., Toonstra, J., Werner, J. L., Mattacola, C. G., Howell, D. M., & Howard, J. S. (2018). Decision to Return to Sport After Anterior Cruciate Ligament Reconstruction, Part I: A Qualitative Investigation of Psychosocial Factors. *Journal of Athletic Training*, *53*(2), 1062-6050-313–316. doi: 10.4085/1062-6050-313-16

Cupal, D. D., & Brewer, B. W. (2001). Effects of relaxation and guided imagery on knee strength, re-injury anxiety, and pain following anterior cruciate ligament reconstruction. *Rehabilitation Psychology*, *46*(1), 28–43. doi: 10.1037/0090-5550.46.1.28

DiSanti, J., Lisee, C., Erickson, K., Bell, D., Shingles, M., & Kuenze, C. (2018). Perception of rehabilitation and return to sport among high school athletes with anterior cruciate ligament reconstruction: qualitative research study. *Journal of Orthopaedic & Sports Physical Therapy*, *48*(12), 951–959. doi: 10.1017/CBO9781107415324.004

Ekstrand, J., Hägglund, M., & Waldén, M. (2011). Epidemiology of muscle injuries in professional football (soccer). *American Journal of Sports Medicine*, *39*(6), 1226–1232. doi: 10.1177/0363546510395879

Everhart, J. S., Best, T. M., & Flanigan, D. C. (2015). Psychological predictors of anterior cruciate ligament reconstruction outcomes: a systematic review. *Knee Surgery, Sports Traumatology, Arthroscopy*, *23*(3), 752–762. doi: 10.1007/s00167-013-2699-1

Feeley, B. T., Kennelly, S., Barnes, R. P., Muller, M. S., Kelly, B. T., Rodeo, S. A., & Warren, R. F. (2008). Epidemiology of National Football League training camp injuries from 1998 to 2007. *The American Journal of Sports Medicine*, *36*(8), 1597–1603. doi: 10.1177/0363546508316021

Grindem, H., Snyder-Mackler, L., Moksnes, H., Engebretsen, L., & Risberg, M. A. (2016). Simple decision rules can reduce re-injury risk by 84% after ACL reconstruction: The Delaware-Oslo ACL cohort study. *British Journal of Sports Medicine*, *50*(13), 804–808. doi: 10.1136/bjsports-2016-096031

Harput, G., Ulusoy, B., Ozer, H., Baltaci, G., & Richards, J. (2016). External supports improve knee performance in anterior cruciate ligament reconstructed individuals with higher kinesiophobia levels. *Knee*, *23*(5), 807–812. doi: 10.1016/j.knee.2016.05.008

Houston, M., Hoch, J., & Hoch, M. (2017). Collegiate athletes with ankle sprain history exhibit increased fear-avoidance beliefs. *Journal of sport rehabilitation, 27*(5), 419-423.

Houston, M. N., Van Lunen, B. L., & Hoch, M. C. (2014). Health-related quality of life in individuals with chronic ankle instability. *Journal of Athletic Training*, *49*(6), 758–763. doi: 10.4085/1062-6050-49.3.54

Hsu, C. J., Meierbachtol, A., George, S. Z., & Chmielewski, T. L. (2017). Fear of re-injury in athletes: implications for rehabilitation. Sports health, 9(2), 162-167.

Kosy, J., Phillips, J., Edordu, A., Pankhania, R., Schranz, P., & Mandalia, V. (2019). Failure to return to preinjury activity level after hamstring anterior cruciate ligament reconstruction: Factors involved and considerations in goal setting. *Indian Journal of Orthopaedics*, *53*(6), 714–720. doi: 10.4103/ortho.IJOrtho_186_18

Kvist, J., Ek, A., Sporrstedt, K., & Good, L. (2005). Fear of re-injury: A hindrance for returning to sports after anterior cruciate ligament reconstruction. *Knee Surgery, Sports Traumatology, Arthroscopy*, *13*(5), 393–397. doi: 10.1007/s00167-004-0591-8

Lentz, T. A., Zeppieri, G., George, S. Z., Tillman, S. M., Moser, M. W., Farmer, K. W., & Chmielewski, T. L. (2015). Comparison of physical impairment, functional, and psychosocial measures based on fear of re-injury/lack of confidence and return-to-sport status after ACL reconstruction. *American Journal of Sports Medicine*, *43*(2), 345–353. doi: 10.1177/0363546514559707

Maddison, R., Prapavessis, H., & Clatworthy, M. (2006). Modeling and rehabilitation following anterior cruciate ligament reconstruction. *Annals of Behavioral Medicine*, (17).

Masten, R., Tušak, M., Stražar, K., Zupanc, O., Drobnič, M., Marinšek, M., & Kandare, M. (2014). Psychological Factors of Rehabilitation of Athletes After Knee Injury. *Slovenian Journal of Public Health*, *53*(3), 226–236.

Miller, R., Kori, S., & Todd, D. (1991). The Tampa Scale for Kinesiophobia. *The Clinical Journal of Pain, 7*(1), 51.

Mosler, A. B., Weir, A., Serner, A., Agricola, R., Eirale, C., Farooq, A., … Crossley, K. M. (2018). Musculoskeletal Screening Tests and Bony Hip Morphology Cannot Identify Male Professional Soccer Players at Risk of Groin Injuries A 2-Year Prospective Cohort Study. *The American journal of sports medicine, 46*(6), 1294-1305.

Orchard, J., Seward, H., & Orchard, J. (2013). Results of 2 decades of injury surveillance and public release of data in the Australian Football League. *American Journal of Sports Medicine*, *41*(4), 734–741. doi: 10.1177/0363546513476270

Sonesson, S., Kvist, J., Ardern, C., Österberg, A., & Silbernagel, K. G. (2017). Psychological factors are important to return to pre-injury sport activity after anterior cruciate ligament reconstruction: expect and motivate to satisfy. *Knee Surgery, Sports Traumatology, Arthroscopy*, *25*(5), 1375–1384. doi: 10.1007/s00167-016-4294-8

Sullivan, M. J. L., Bishop, S. R., & Pivik, J. (1995). The Pain Catastrophizing Scale: Development and validation. *Psychological Assessment*, *7*(4), 524–532. doi: 10.1037/1040-3590.7.4.524

Te Wierike, S. C. M., Van Der Sluis, A., Van Den Akker-Scheek, I., Elferink-Gemser, M. T., & Visscher, C. (2013). Psychosocial factors influencing the recovery of athletes with anterior cruciate ligament injury: A systematic review. *Scandinavian Journal of Medicine and Science in Sports*, *23*(5), 527–540. doi: 10.1111/sms.12010

Thomeé, P., Währborg, P., Börjesson, M., Thomeé, R., Eriksson, B. I., & Karlsson, J. (2006). A new instrument for measuring self-efficacy in patients with an anterior cruciate ligament injury. *Scandinavian Journal of Medicine and Science in Sports*, *16*(3), 181–187. doi: 10.1111/j.1600-0838.2005.00472.x

Vranceanu, A. M., Bachoura, A., Weening, A., Vrahas, M., Smith, R. M., & Ring, D. (2014). Psychological factors predict disability and pain intensity after skeletal trauma. *Journal of Bone and Joint Surgery - Series A*, *96*(3), 1–6. doi: 10.2106/JBJS.L.00479

Webster, K. E., McPherson, A. L., Hewett, T. E., & Feller, J. A. (2019). Factors Associated With a Return to Preinjury Level of Sport Performance After Anterior Cruciate Ligament Reconstruction Surgery. *American Journal of Sports Medicine*, *47*(11), 2557–2562. doi: 10.1177/0363546519865537

Werner, J. L., Burland, J. P., Mattacola, C. G., Toonstra, J., English, R. A., & Howard, J. S. (2018). Decision to Return to Sport Participation After Anterior Cruciate Ligament Reconstruction, Part II: Self-Reported and Functional Performance Outcomes. *Journal of Athletic Training*, *53*(5), 464–474. doi: 10.4085/1062-6050-328-16

Wiese-bjornstal, D. M., Smith, A. M., Shaffer, S. M., & Morrey, M. A. (1998). An integrated model of response to sport injury: Psychological and sociological dynamics. *Journal of Applied Sport Psychology*, *10*(1), 46–69. doi: 10.1080/10413209808406377

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Wakeup Call: Reviewing the Effects of Sleep on Decision-Making in Athletes and Implications for Sports Officials

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ABSTRACT Although sports officials are essential in the adjudication of rules during competitions, research into officiating populations is preliminary. This review explores existing research on the effects of sleep loss on decision-making in athlete populations, to gain relevant insight into sports officials and the growing decision-making demands of their role. Specifically, cognitive factors that influence decision-making are identified, and the potential relationship between sleep/wake behaviours and decision-making in sports officials were examined. Particular focus was granted to sleep, specifically sleep restriction in athlete populations, and the hypothesized relationship between sleep/wake behaviours and decision-making in sports officials. Impaired sleep duration and quality has been shown to impair cognitive performance. In the context of sport, impairments to sleep can negatively impact motivation, physical strength, reaction time, and decision-making, all of which are imperative to the role of the sports official. Despite numerous studies demonstrating that sleep loss reduces cognitive performance in athletes, this review revealed that similar research in sports officials has surprisingly yet to be conducted. Since sports officials require a high level of cognitive and physical skills to make correct decisions, an inquiry into the influence of sleep on cognitive performance may encourage research that facilitates improved performance training methods for decision-making in officials. Such findings are important to maintain the standard of officiating and allow for the development of guidelines and strategies to manage sleep and optimize decision-making across various sporting codes.

KEY WORDS referee, umpire, mood, motivation, competition

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Introduction

As the professional and recreational market of sport is under more pressure than ever, the need to enforce rules and regulation in sporting events has paralleled the lucrative shift in athletic competition (Stewart & Smith, 2000). Such regulation is heavily controlled by the sports official. The sports official is fundamental to the regulation of competition in sport, by administering the rules, which influence overall match results based on their adjudication of play and decision-making. Furthermore, officials carry an ethical responsibility that preserves the intrinsic value of sport and competition, all under the watchful eye of athletes, coaches, spectators, and the entire audience of a broadcasted competition (Page & Page, 2010; Isidori, Muller, & Kaya, 2012).

Despite the crucial role of sports officials, they have not been extensively considered in research. While athletes often physically benefit from interchanges during competition, audiences seemingly discount the fact that sports officials are required to complete an entire match, limiting their opportunity to recover between

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bouts of high-intensity activity (Heinemann, 1990; MacMahon et al., 2014; Pina, Passo, & Maynard, 2018). Sports officials have a range of demands to consider during competition, their role in evaluating technical code, decision-making, and enduring physical demands are consistently present across sports (MacMahon, Helsen, Starkes, & Weston, 2007; MacMahon et al., 2014).

Since the adjudication of rules is imperative to the role of sports officials, this review will examine their decision-making, including the underlying cognitive factors involved. It is important to note, due to the limited research on this topic, this review will consider key findings reported in athlete populations where relevant. Furthermore, given the well-established importance of sleep to cognitive performance (Belenky et al., 2003; Rogers, Dorrian, & Dinges, 2003), particular focus will be given to sleep in this review. Specifically, sleep restriction in athlete populations and the potential relationship between sleep/wake behaviours and decision-making in sports officials will be discussed.

This narrative review searched for sleep and decision-making research conducted in both athletes and sports officials. Although narrative, the source articles were identified using a systematic search strategy. The online databases Cochrane, MEDLINE (Pubmed), Scopus and Web of Science for scientific papers were searched using keywords, including "sleep" and "decision" in combination with "athlete", "sport", and "sports official". Relevant references were inspected and limited to peer-reviewed papers published in English from 1981 to 2020.

Decision-making in sports officials

Decision-making in sport requires sports officials to possess a high level of rule knowledge and application (MacMahon et al., 2007). MacMahon and Plessner (2013) categorized sports officials into three main types; interactors, reactors, and monitors, based on their interaction with athletes and the number of signals being monitored. Interactors enforce competition rules, such as soccer officials, reactors play a perceptual role in monitoring specific competition codes, such as tennis line judges, and monitors observe and assess the quality of performance, for example, gymnastic judges (MacMahon & Plessner, 2013). Despite these variations in duty across sports, officials all share a common process – decision-making – defined as the ability to integrate information to plan, judge, and execute an action (Causer & Ford, 2014; MacMahon & Plessner, 2013).

On occasions, the decision-making requirements of sports officials may be relatively simple. However, it is common for sports officials to undertake complex decision-making processes, requiring a high level of rule interpretation. Recent studies have examined the extent of decision-making during competition, with 887 decisions made by officials during an Australian Football League match (Neville, Salmon & Read, 2007), and approximately 140 observable decisions made by officials during an international soccer match (Helsen & Bultynck, 2004). In the latter study, Helsen and Bultynck (2004) showed the number of decisions made by soccer officials was uniformly distributed throughout competition, asserting the need for officials to exercise complete focus for for an entire match (Helsen & Bultynck, 2004). While this study provides a preliminary investigation into the decision-making demands of sports officials, it forms a very limited body of research from which to draw definitive conclusions. These decisions, made under highly stressful and time-sensitive circumstances, can have a large impact on overall match outcome, athlete safety, spectatorship, and sponsorship (Page & Page, 2010). Recently, the Federation Internationale de Football Association (2019) introduced the Video Assistant Referee (VAR) to help referees in reviewing decisions made by the head referee. However, this approach has been met with some controversy. For example, Nevill et al. (2002) found that referees who viewed videotaped fouls with crowd noise called significantly fewer fouls for the away team than those presented only with video. It is evident that accurate effectiveness of the VAR is still in its infancy, and further research is required to examine its efficacy (Carlos et al., 2019). Further research is also needed to understand the relationship between sleep and decision-making in the VAR context. Regardless, sports officials, whether video assistants or head officials, are vital members of their sports and are recognized as performers in their own right (Morris & O'Connor, 2017).

While the demands of the sports official role continue to grow, the pressure of officials to reduce decision-making errors parallels such growth (Dickson, 2002). Studies have reported soccer officials attain 86% accuracy in decision-making during competition (Mallo, Frutos, Juarez, & Navarro, 2012), whereas Australian football umpires reported 84% accuracy when awarding free kicks during competition (Elsworthy, Burke, Scott, Stevens, & Dascombe, 2014). Regardless of this need for high-quality officiating and decision-making, recent studies have focused on the physical and cognitive factors underpinning decision-making processes in athletes across sports (Almonroeder, Tighe, Miller, & Lanning, 2018; Konishi et al., 2017; Scanlan, Humphries, Tucker, & Dalbo, 2014). Because the cognitive skills of athletes and sports officials are specific to their roles, the prevailing research on athletes should not be considered completely transferable to sports officials (Williams & Davids, 1995).

Physical, environmental, and psychological demands have been recognized as defining factors for decision-making performance in sports officials (Larkin, Mesagno, Berry, & Spittle, 2018). To understand officiating performance, Mascarenhas et al. (2005) developed a model identifying five common themes: (i) knowledge and application of competition code; (ii) physical fitness; (iii) personality and match management; (iv) contextual judgement; and (v) psychological characteristics. While these themes provide a framework to identify factors that contribute to performance and are theoretically relevant to decision-making ability, they do not describe how such contextual factors might affect the underlying cognitions of decision-making or

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inform and improve the process. Understanding the factors that improve decision-making and the integration of information to enforce competition rules is vital for providing a high standard of decision-making in officials (Helsen & Bultynck, 2004; Williams & Davids, 1995).

While some studies have examined the impact of contextual factors such as match-bias or rule changes on decision-making, cognitive factors that also influence decision-making in officials have been less explored (Plessner & Haar, 2006). In general adult populations, an increased interest in the role of mood, stress, fatigue, and sleep on decision-making ability has emerged (Loewenstein & Lerner, 2003). In a review by Loewenstein and Lerner (2003), cognitive factors significantly impacted decision-making, with incidental and unexpected emotions and stress affecting decision-making quality. These underlying cognitive factors of decision-making are recognized as significant indicators of an individual's ability to respond to a situation, not only because of the positive effect experienced by the individual, but also their ability to utilize such mechanisms to deal with and influence decision-making (Loewenstein & Lerner, 2003; Xing & Sun 2013).

With sports officials, early investigations focused on the influence of common sources of stress on physical and cognitive performance (Taylor, Daniel, Leith & Burke, 1990; Rainey & Hardy, 1999; MacMahon et al., 2014; Pina, Passo, & Maynard, 2018). Taylor et al. (1990) found that stressors, such as a lack of appreciation from spectators, athletes, and coaches, contributed to burnout and high turnover rates in soccer officials. Furthermore, younger sports officials reported greater burnout than older sports officials, which was attributed to older sports officials possessing more effective coping mechanisms. Such findings were later supported by Rainey and Hardy (1999), who reported stress-reducing strategies, such as relaxation or self-regulation techniques, reduced burnout and minimized the decline of cognitive and physical performance in rugby union officials. While interpersonal conflicts and the fear of failure are considered the most stressful influences on sports officials, these factors demonstrated small to moderate relationships with stress and burnout rates (Rainey & Hardy, 1999; Taylor et al., 1990). In fact, studies indicate sports officials experience changing and differing amounts of stress, and the effect of stress on officiating performance is speculative using evidence provided in generic populations (Mascarenhas et al., 2005; Rainey & Winterich, 1995; Stewart & Ellery, 1996).

Suggested cognitive factors that influence decision-making in sports officials include prior decisions, fatigue due to travel, and athlete attitudes (Mascarenhas et al., 2005). While these external influences provide insight into broader psychological phenomena, they do not provide direct evidence on whether psychological factors facilitate decision-making in officials. Research has produced conclusions applicable to general populations or athletes on this matter (Akerstedt, 2007; Almonroeder et al., 2018; Durmer & Dinges, 2005) however, future research is required to attribute such conclusions to sports officials. In turn, a cognitive factor that is routinely demonstrated as having a significant impact on decision-making abilities in the general population is sleep (Akerstedt, 2007; Almonroeder et al., 2018; Weston et al., 2012).

Sleep and decision-making

Sleep, defined as a homeostatic behavioural state of reduced movement and sensory reaction that repeatedly reoccurs at 24-hour intervals, is widely regarded as critical to cognitive and physiological function (Gordijn & Beersma, 2007). The effects of sleep on human cognition and motor functioning are well recognized (Daviaux, Mignardot, Cornu, & Deschamps, 2014; Frey, Badia, & Wright Jr, 2004; Rogers et al., 2003). Sleep has many psychological and physiological functions, with a recommended duration of seven to nine hours per day in adults (Hirshkowitz et al., 2015; Watson et al., 2015). Studies have shown mood, fatigue, and cognitive function are routinely impaired by sleep quality, partial sleep restriction, or total sleep deprivation in general populations (Akerstedt, 2007; Frey et al., 2004; Rogers et al., 2003).

Sleep quality, a subjective rating of the efficiency and maintenance of sleep, has been shown to influence physical and cognitive function in general populations (Nebes, Buysse, Halligan, Houck, & Monk, 2009) and athlete populations (Brandt, Bevilacqua, & Andrande, 2017; Peppard, Barnet, Rasmuson, Bliwise, & Hagen, 2017). For instance, Peppard et al. (2017) reported significant positive correlations between sleep quality and cognition, specifically memory, executive function, and attention in the general population. However, this study did not account for common conditions that impair sleep and cognition, such as illness, medication, or psychological disorders (Nebes et al., 2009). In this regard, Nebes et al. (2009) analysed the relationship between cognitive performance and the duration of sleep in older adults from the general population while controlling for confounding conditions. Significant positive correlations were reported between sleep quality and cognitive performance, with no significant relationship observed between sleep duration and cognitive performance (Nebes et al., 2009). Consequently, the results of this study highlight the specific need for future investigations to consider the impact of sleep quality on cognitive function.

Reduced sleep duration impacts specific domains of cognitive performance, including increased memory lapses, cognitive slowing, memory impairment, and decreased vigilance, attention, response time, and capability (Chua et al., 2014). Scott, McNaughton, and Polman (2006) examined the effect of 30-hour sleep deprivation on cognitive and psychomotor function compared to normal sleep in a general adult population. Significant disturbances in mood, reaction time, vigour, and mental fatigue were apparent following sleep deprivation. Although studies tend to focus on the effects of sleep deprivation on cognitive performance, sleep restriction is a more common experience in general adult populations (Demos et al., 2016). Indeed, Demos et al. (2016) showed that following restricted sleep, decision-making remained unaffected, yet participants were 30% more likely to make errors in cognitive ability tasks. Consequently, sleep restriction, like sleep deprivation, impaired reaction time and impulsive actions. This collective evidence suggests that reductions in sleep diminish reaction time, alertness, and cognitive performance (Demos et al., 2016; Scott et al., 2006).

Given that sleep restriction is common in athlete populations, examining the implications of this pattern on cognitive performance is paramount (Blumert et al., 2007; Jarraya et al., 2013; Skein et al., 2013). Restrictions to sleep can negatively impact cognitive performance, reaction time, and decision-making – all of which are essential to the role of athletes (Hirshkowitz et al., 2015; Jarraya et al., 2013; Reilly & Edwards, 2007; Scott, McNaughton, & Polman, 2006). Blumert et al. (2007) investigated the effect of 24 hours of sleep deprivation on physical performance and mood in national college weightlifters. Sleep deprivation had no significant influence on physical performance but substantially affected mood state. Similarly, Skein et al. (2013) showed 24 hours of sleep deprivation significantly deteriorated reaction time and accuracy during a word colour recognition test due to reduced alertness and attention in rugby league athletes following competition. While these studies show the impact of sleep deprivation on cognitive performance, the simulated overnight sleep deprivation adopted within the respective methodologies limit the representation of common sleep disruptions encountered by athletes (Blumert et al., 2007; Skein et al., 2013). In this regard, Jarraya et al. (2013) examined the effect of sleep restriction on cognitive performance in handball goalkeepers. Athletes were monitored morning and night following regular sleep and restricted sleep, after which they completed three cognitive tasks. Sleep restriction resulted in significantly poorer reaction time, selective attention, and constant attention, with greater changes observed at night compared to morning demonstrating an additive effect of timing on performance.

Given the majority of research investigating the impact of sleep on cognitive performance has utilized simulated laboratory environments, it is necessary to examine sleep and cognition in a real-world competitive context (Blumert et al., 2007; Jarraya et al., 2013). In doing so, findings on sleep and cognitive performance will carry stronger ecological validity. Further studies should consider utilizing cognitive measures that consider sporting environments to closely parallel the context of competition to establish more definitive conclusions.

Sleep restriction in sport

In sport, sleep restriction provides realistic insights into the experiences of athletes and sports officials. Sleep restriction can negatively impact physical strength and performance, mood, motivation, reaction time, and decision-making in athletes (Lastella, Lovell, & Sargent, 2014; Martin, 1981; Samuels, 2012; Thun, Bjorvatn, Flo, Harris, & Pallesen, 2015; Reilly & Edwards, 2007). These findings are highly relevant to sporting performance as factors such as stress, travel for matches, nervousness prior to competition, and sleeping in unfamiliar environments can significantly curb sleep duration and quality (Pallesen et al., 2017). A crucial element of training and recovery in athletes is sleep management, as disturbances to sleep potentially compromise athletic performance, cognitive function, mood, and injury risk (Durmer & Dinges, 2005; Erlacher, Ehrlenspiel, Adegbesan, & El-Din, 2011).

Unavoidable circumstances can disturb sleep in athletes. Eagles et al. (2016) explored the effect of competition on the duration and efficiency of sleep in professional rugby union athletes. Significant reductions in sleep duration on nights following competition were observed, particularly when matches were played in the evening (Eagles et al., 2016). While sleep was negatively impacted following competition, findings were limited by the lack of definition for "non-game nights" (i.e., nights before a competition or nights before no competition). Furthermore, home matches were exclusively examined, and since it is common for competitions to be held at away venues, representation of a competitive season was somewhat limited (Eagles et al., 2016).

Similarly, Juliff et al. (2015) reported a significant reduction in sleep duration on nights before a competition in athletes from individual and team sports, with thoughts about competition and nervousness identified as the main mechanisms interfering with sleep. The investigated athletes also reported being unaware of strategies to overcome poor sleep, possibly highlighting the need for further monitoring and education of sleep in athlete populations (Juliff et al., 2015). While these studies collectively demonstrate that sleep in sporting environments is dependent on the time of competition (day versus night), and sampled night (habitual versus before competition versus after competition), there is yet to be a broad analysis of how all these factors interact and impact sleep in athletes and sports officials (Eagles et al., 2016; Juliff et al., 2015). A comprehensive investigation into the impact of time of competition on sleep outcomes in sports officials should be considered in future studies.

The need to examine sleep and decision-making in sports officials

Data examining decision-making in sports officials have attributed performance to contextual factors such as time of competition, regulations, and athlete attitudes (Helsen & Bultynck, 2004; Larkin et al., 2018). Sports officials need to have exceptional cognitive skills to make correct decisions; thus, inquiry to identify factors that influence decision-making, such as sleep, is necessary and long overdue in this population. Future investigation of sleep restriction on cognitive performance in sports officials will not only extend knowledge but allow for improved strategies to enhance decision-making ability and overall sport competition (Williams & Davids, 1995).

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Cognitive distress, anxiety, and common mental health conditions in athlete populations have gained increased attention in research (Gouttebarge, Backx, Aoki, & Kerkhoffs, 2015; Junge & Feddermann-Demont, 2016), while empirical evidence about the psychology of sports officials remains limited (Gouttebarge, Johnson, Rochcongar, Rosier, & Kerkhoffs, 2017). The lack of research on officials is surprising, considering they perform in difficult psychosocial environments involving stressors such as physical energy, social pressure, and spectator scrutiny. It is common for sports officials across all playing levels to hold dual occupations, thus exacerbating pressures beyond the context of competition. In a study comparing common mental health concerns of athletes and sports officials, officials were found to have a high risk of mental health concerns similar to athletes (Gouttebarge et al., 2017). While this study was specific to soccer officials and therefore may not be generalizable to other sports, the results suggested specific training and support measures for sports officials should be introduced. Consequently, the authors concluded that role-specific management and training protocols were necessary to improve the psychological performance and well-being within and beyond the context of competition in sports officials (Gouttebarge et al., 2017).

Sleep has been consistently recognized to influence decision-making (Demos et al., 2016; Nebes et al., 2009; Scott et al., 2006), and while athlete populations have been identified as experiencing poor sleep duration and quality compared to general populations (Blumert et al., 2007; Jarraya et al., 2013; Skein et al., 2013), the underlying relationship between sleep and decision-making in sports officials has yet to be examined. Not only is such future research important to maintain the integrity of sport performance, but it may provide an opportunity to improve the standard of officiating in sport (Hancock, Rix-Lievre, & Cote, 2015; Catteuw, Helsen, Gilis, & Wagemans, 2009). This knowledge will also allow for the development of guidelines and strategies to help manage sleep and optimize decision-making in officials across various sporting codes.

References

Akerstedt, T. (2007). Altered sleep/wake patterns and mental performance. *Physiology and Behaviour, 90*, 209-218. doi: 10.1016/j.physbeh.2006.09.007

Almonroeder, T., Tighe, S., Miller, T., & Lanning, C. (2020). The influence of fatigue on decision-making in athletes: A systematic review. *Sports Biomechanics*, *19*(1), 76-89. doi: 10.1080/14763141.2018.1472798

Belenky, G., Wesensten, N., Thorne, D., Thomas, M., Sing, H., Redmond, D., Russo, M., & Balkin, T. (2003). Patterns of performance degradation and restoration during sleep restriction and subsequent recovery: A sleep dose-response study. *Journal of Sleep Research, 12*(1), 1-12. doi: 10.1046/j.1365-2869.2003.00337.x

Blumert, P., Crum, A., Ernsting, M., Volek, J., Hollander, D., Haff, E., & Haff, G. (2007). The acute effects of twenty-four hours of sleep loss on the performance of national-caliber male collegiate weightlifters. *Journal of Strength and Conditioning Research, 21*(4), 1146-1154. doi: 10.1519/R-21606.1

Brandt, R., Bevilacqua, G., & Andrande, A. (2017). Perceived sleep quality, mood states, and their relationship with performance among Brazilian elite athletes during a competitive period. *Journal of Strength and Conditioning Research, 31*(4), 1033-1039. doi: 10.1519/JSC.0000000000001551

Carlos L-P., Ezequiel R., & Anton, K. (2019). How does Video Assistant Referee (VAR) modify the game in elite soccer? *International Journal of Performance Analysis in Sport*, 19(4), 646-653. doi: 10.1080/24748668.2019.1646521

Catteuw, P., Helsen, W., Gilis, B., & Wagemans, J. (2009). Decision-making skills, role specificity, and deliberate practice in association football refereeing. *Journal of Sports Sciences, 27*(11), 1125-1136. doi: 10.1080/02640410903079179

Causer, J., & Ford, P. (2014). "Decisions, decisions, decisions": Transfer and specificity of decision-making skill between sports. *Cognitive Process, 15*(3), 385-389. doi: 10.1007/s10339-014-0598-0

Chua, E., Yeo, S., Lee, I., Tan, L., Lau, P., Cai, S., Zhang, X., Puvanendran, K., & Gooley, J. (2014). Sustained attention performance during sleep deprivation associates with instability in behavior and physiologic measures at baseline. *Sleep Research Society, 37*(1), 27-39. doi: 10.5665/sleep.3302

Daviaux, Y., Mignardot, J., Cornu, C., & Deschamps, T. (2014). Effects of total sleep deprivation on the perception of action capabilities. *Experimental Brain Research, 232*(7), 2243-2253. doi: 10.1007/s00221-014-3915-z

Demos, K., Hart, C., Sweet, L., Mailloux, K., Trautvetter, J., Williams, S., Wing, R., & McCaffery, J. (2016). Partial sleep deprivation impacts impulsive action but not impulsive decision-making. *Physiology and Behavior, 164*(PtA), 214-219. doi: 10.1016/j.physbeh.2016.06.003

Dickson, S. (2002). *How good are elite soccer referees? Just ask the players and coaches!* In W. Spink (Ed.), Science and football IV. London: Routledge.

Durmer, J. S., & Dinges, D. F. (2005). Neurocognitive consequences of sleep deprivation. *Seminars in Neurology, 25*(1), 117-129. doi: 10.1055/s-2005-867080

Eagles, A., McIellan, C., Hing, W., Carloss, N., & Lovell, D. (2016). Changes in sleep quantity and efficiency in professional rugby union players during home based training and match-play. *The Journal of Sports Medicine and Physical Fitness, 56*(5), 565-571. Retrieved from https://www.ncbi.nlm.nih.gov/pubmed/25369280

Elsworthy, N., Burke, D., Scott, B., Stevens, C., & Dascombe, B. (2014). Physical and decision-making demands of Australian football umpires during competitive matches. *Journal of Strength and Conditioning Research, 28*(12), 3502-3507. doi: 10.1519/JSC.0000000000000567

Erlacher, D., Ehrlenspiel, F., Adegbesan, O., & El-Din, H. (2011). Sleep habits in German athletes before important

competitions or games. *Journal of Sports Sciences, 29*(8), 859-866. doi: 10.1080/02640414.2011.565782
Fédération Internationale de Football Association. (2019). *Laws of the game: Video Assistant Referee (VAR) protocol* (pp. 134–142). Zurich: FIFA.
Frey, D., Badia, P., & Wright Jr, K. (2004). Inter and intra-individual variability in performance near the circadian nadir during sleep deprivation. *Journal of Sleep Research, 13*(4), 305-315. doi: 10.1111/j.1365-2869.2004.00429.x
Gordijn, M., & Beersma, D. (2007). Circadian control of the sleep–wake cycle. *Physiology and Behaviour, 90*(2-3), 190-195. doi: 10.1016/j.physbeh.2006.09.010
Gouttebarge, V., Backx, F., Aoki, H., & Kerkhoffs, G. (2015). Symptoms of common mental disorders in professional football (soccer) across five European countries. *Journal of Sports Science and Medicine, 14*(4), 811-818. doi: 10.1080/00913847.2017.1248796
Gouttebarge, V., Johnson, U., Rochcongar, P., Rosier, P., & Kerkhoffs, G. (2017). Symptoms of common mental disorders among professional football referees: A one-season prospective study across Europe. *The Physician and Sports Medicine, 45*(1), 11-16. doi: 10.1080/00913847.2017.1248796
Hancock, D., Rix-Lievre, G., & Cote, J. (2015). Citation network analysis of research on sport officials: A lack of interconnectivity. *International Review of Sport and Exercise Psychology, 8*(1), 95-105. doi: 10.1080/1750984X.2015.1022202
Heinemann, K. (1990). *Introduction to sport sociology.* Schorndorf: Hofmann.
Helsen, W., & Bultynck, J.-B. (2004). Physical and perceptual-cognitive demands of top-class refereeing in association football. *Journal of Sports Sciences, 22*(2), 179-189. doi: 10.1080/02640410310001641502
Hirshkowitz, M., Whiton, K., Albert, S. M., Alessi, C., Bruni, O., Doncarlos, L., Hazen, N., Herman, J., Katz, E., & Kheirandish-Gozal, L. (2015). National Sleep Foundation's sleep time duration recommendations: Methodology and results summary. *Sleep Health, 1*(1), 40-43. doi: 10.1016/j.sleh.2014.12.010
Isidori, E., Muller, A., & Kaya, S. (2012). The referee as educator: Hermeneutical and pedagogical perspectives. *Physical Culture and Sport, 56*(1), 5-11. doi: 10.2478/v10141-012-0023-2
Jarraya, S., Jarraya, M., Chtourou, H., & Souissi, N. (2013). Effect of time of day and partial sleep deprivation on the reaction time and the attentional capacities of the handball goalkeeper. *Biological Rhythm Research, 45*(2), 183-191. doi: 10.1080/09291016.2013.787685
Juliff, L., Halson, S., & Peiffer, J. (2015). Understanding sleep disturbance in athletes prior to important competitions. *Journal of Science and Medicine in Sport, 18*(1), 13-18. doi: 10.1016/j.jsams.2014.02.007
Junge, A., & Feddermann-Demont, N. (2016). Prevalence of depression and anxiety in top-level male and female football players. *BMJ Open Sport and Exercise Medicine, 2*(1), 1-7. doi: 10.1136/bmjsem-2015-000087
Konishi, K., Kimura, T., Yuhaku, A., Kurihara, T., Fujimoto, M., Hamaoka, T., & Sanada, K. (2017). Effect of sustained high-intensity exercise on executive function. *The Journal of Physical Fitness and Sports Medicine, 6*(2), 111-117. doi: 10.7600/jpfsm.6.111
Larkin, P., Mesagno, C., Berry, J., & Spittle, M. (2018). Exploration of the perceptual-cognitive processes that contribute to in-game decision-making of Australian football umpires. *International Journal of Sport and Exercise Psychology, 16*(2), 112-124. doi: 10.1080/1612197X.2016.1167760
Lastella, M., Lovell, G., & Sargent, C. (2014). Athletes' precompetitive sleep behavior and its relationship with subsequent precompetitive mood and performance. *European Journal of Sport Science, 14*(1), 123-130. doi: 10.1080/17461391.2012.660505
Loewenstein, G., & Lerner, J. S. (2003). The role of affect in decision making. In R. Davidson, H. Goldsmith, & K. Scherer (Ed.), *Handbook of Affective Science* (pp. 619-642). Oxford, Oxford University Press.
MacMahon, C., & Plessner, H. (2013). The sport official in research and practice. In C. MacMahon, D. Farrow, & J. Baker, *Developing sport expertise - researchers and coaches put theory into practice.* London: Routledge.
MacMahon, C., Helsen, W., Starkes, J., & Weston, M. (2007). Decision-making skills and deliberate practice in elite association football referees. *Journal of Sports Sciences, 25*(1), 65-78. doi: 10.1080/02640410600718640
MacMahon, C., Mascarhenhas, D., Plessner, H., Pizzera, A., Oudejans, R., & Raab, M. (2014). *Sport officials and officiating: Science and practice*. NY: Routledge.
Mallo, J., Frutos, P., Juarez, D., & Navarro, E. (2012). Effect of positioning on the accuracy of decision making of association football top-class referees and assistant referees during competitive matches. *Journal of Sports Sciences, 30*(13), 1437-1445. doi: 10.1080/02640414.2012.711485
Martin, B. (1981). Effect of sleep deprivation on tolerance of prolonged exercise. *European Journal of Applied Physiology and Occupational Physiology, 47*(4), 345-354, doi: 10.1007/BF02332962
Mascarenhas, D., Collins, D., & Mortimer, P. (2005). Elite refereeing performance: Developing a model for sport science support. *The Sport Psychologist, 19*(4), 364-379. doi: 10.1123/tsp.19.4.364
Mascarenhas, D., O'hare, D., & Plessner, H. (2006). The psychological and performance demands of association football refereeing. *International Journal of Sport Psychology, 37*(2), 99-120. doi: 10.2174/1875399X0090201000
Morris, G., & O'Connor, D. (2017). Key attributes of expert NRL referees. *Journal of Sports Sciences, 35*(9), 852-857. doi: 10.1080/02640414.2016.1194524
Nebes, R., Buysse, D., Halligan, E., Houck, P., & Monk, T. (2009). Self-reported sleep quality predicts poor cognitive performance in healthy older adults. *The Journals of Gerontology, 64B*(2), 180-187. doi: 10.1093/geronb/gbn037
Nevill, A. M., Balmer, N. J., & Williams, A. M. (2002). The influence of crowd noise and experience upon

refereeing decision in football. *Psychology of Sport and Exercise*, 3, 261–272.

Neville, T., Salmon, P., & Read, G. (2017). Analysis of in-game communication as an indicator of recognition primed decision making in elite Australian rules football umpires. *Journal of Cognitive Engineering and Decision Making, 11*(1), 81-96. doi: 10.1177/1555343416672557

Page, K., & Page, L. (2010). Alone against the crowd: Individual differences in referees' ability to cope under pressure. *Journal of Economic Psychology*, 31(2), 192-199. doi: 10.1016/j.joep.2009.08.007

Pallesen, S., Gundersen, H., Kristoffersen, M., Bjorvatn, B., Thu, E., & Harris, A. (2017). The effects of sleep deprivation on soccer skills. *Perceptual and Motor Skills, 124*(4), 812-929. doi: 10.1177/0031512517707412

Peppard, P., Barnet, J., Rasmuson, A., Bliwise, D., & Hagen, E. (2017). Sleep duration and quality are associated with cognitive performance in midlike and older adulthood. *Sleep Medicine, 40*(1), 258. doi: 10.1016/j.sleep.2017.11.756

Pina, J., Passos, A., Araújo, D., & Maynard, M. (2018). Football refereeing: An integrative review. *Psychology of Sport and Exercise*, 35, 10-26. doi: 10.1016/j.psychsport.2017.10.006

Plessner, H., & Haar, T. (2006). Sports performance judgments from a social cognitive perspective. *Psychology of Sport and Exercise, 7*(6), 555-575. doi: 10.1016/j.psychsport.2006.03.007

Rainey, D. (1995). Sources of stress, burnout, and intention to terminate among basketball referees. *Journal of Sport Behaviour*, 22(4), 578-590. doi: 10.1080/026404199365515

Rainey, D., & Hardy, L. (1999). Sources of stress, burnout and intention to terminate among rugby union referees. *Journal of Sports Sciences, 17*, 797-806. doi: 10.1080/026404199365515

Rainey, D., & Winterich, D. (1995). Magnitude of stress reported by basketball referees. *Perceptual and Motor Skills, 81*(3), 1241-1242. doi: 10.2466/pms.1995.81.3f.1241

Reilly, T., & Edwards, B. (2007). Altered sleep–wake cycles and physical performance in athletes. *Physiology and Behaviour, 90*(2-3), 274-284. doi: 10.1016/j.physbeh.2006.09.017

Rogers, N., Dorrian, J., & Dinges, D. (2003). Sleep, waking and neurobehavioural performance. *Frontiers in Bioscience, 8*, 1056-1067. doi: 10.2741/1174

Samuels, C. (2012). Jet lag and travel fatigue: a comprehensive management plan for sport medicine physicians and high-performance support teams. *Clinical Journal of Sports Medicine, 22*(3), 268-273. doi: 10.1097/JSM.0b013e31824d2eeb

Scanlan, A., Humphries, B., Tucker, P., & Dalbo, V. (2014). The influence of physical and cognitive factors on reactive agility performance in men basketball players. *Journal of Sports Sciences, 32*(4), 367-374. doi: 10.1080/02640414.2013.825730

Scott, J., McNaughton, L., & Polman, R. (2006). Effects of sleep deprivation and exercise on cognitive, motor performance and mood. *Physiology and Behaviour, 87*(2), 396-408. doi: 10.1016/j.physbeh.2005.11.009

Skein, M., Duffield, R., Minett, G., Snape, A., & Murphy, A. (2013). The effect of overnight sleep deprivation after competitive rugby league matches on postmatch physiological and perceptual recovery. *International Journal of Sports Physiology and Performance, 8*(5), 556-564. doi: 10.1123/ijspp.8.5.556.

Stewart, B., & Smith, A. (2000). Australian sport in a postmodern age. *The International Journal of the History of Sport, 17*(2), 278-304. doi: 10.1080/09523360008714137

Stewart, M., & Ellery, P. (1996). Amount of psychological stress reported by high school volleyball officials. *Perceptual and Motor Skills, 83*(1), 337-338. doi: 10.2466/pms.1996.83.1.337

Taylor, A., Daniel, J., Leith, L., & Burke, R. (1990). Paths from perceived stress to psychological burnout, satisfaction, turnover intentions and actual dropout among soccer officials. *Journal of Applied Sport Psychology, 2*(1), 84-97. doi: 10.1080/10413209008406422

Thun, E., Bjorvatn, B., Flo, E., Harris, A., & Pallesen, S. (2015). Sleep, circadian rhythms, and athletic performance. *Sleep Medicine Reviews, 23*, 1-9. doi: 10.1016/j.smrv.2014.11.003

Watson, N. B. (2015). Joint consensus statement of the American Academy of Sleep Medicine and Sleep Research Society on the recommended amount of sleep for a healthy adult: Methodology and discussion. *Journal of Clinical Sleep Medicine, 11*(8), 931-52. doi: 10.5665/sleep.4886

Weston, M., Castagna, C., Impellizzeri, F., Bizzini, M., Williams, M., & Gregson, W. (2012). Science and medicine applied to soccer refereeing. *Sports Medicine, 42*(7), 615-631. doi: 10.2165/11632360-000000000-00000

Williams, A. M., & Davids, K. (1995). Declarative knowledge in sport: A byproduct of experience or a characteristic of expertise? *Journal of Sport and Exercise Psychology, 7*(3), 259-275. doi: 10.1123/jsep.17.3.259

Xing, C., & Sun, J. (2013). The role of psychological resilience and positive affect in risky decision-making. *International Journal of Psychology, 48*(5), 935-943. doi: 10.1080/00207594.2012.729840

REVIEW PAPER

Benefits of Kinesiology Tape on Tendinopathies: A Systematic Review

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ABSTRACT The purpose of this systematic review was to produce a best evidence synthesis of the effects of Kinesiology Tape (KT) in the treatment of tendinopathies. An electronic search on five databases (PubMed, Cumulative Index to Nursing and Allied Health Literature (CINAHL), Cochrane Library, SportDiscus, and Physiotherapy Evidence Database (PEDro)) was conducted. Studies were included if (1) patients suffered from tendinopathy; (2) isolated KT was applied in at least one group; (3) comparisons between other techniques were developed; (4) outcomes based on pain, function, disability, or quality of life were analysed. Two reviewers independently extracted data and assessed methodological quality using the Physiotherapy Evidence Database (PEDro) scale. A total of 13 articles met the eligibility criteria, involving 454 participants. Nine of these studies presented upper extremity tendinopathies, and four explored lower extremity tendinopathies. Selected papers ranged from low to high quality, with an average score of 5 on the PEDro scale. According to our findings, there is limited evidence to support KT alone for the treatment of tendinopathies beyond the short-term. Due to the mixed methodological quality and the insufficient number of clinical trials, larger, long-term, high-quality studies are needed to support the theory that tendinopathies can benefit from KT applications.

KEY WORDS kinesiotape, bandaging, tendon disorder, kinesiotaping

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KINESIOTAPE ON TENDINOPATHIES: A REVIEW
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Introduction

Tendon disorders are both acute, with partial or complete rupture components (Docheva et al., 2015), and chronic, with a duration of symptoms of greater than months being the most common presentations (Kaux et al., 2011). Nearly 30% of general practice consultations related to musculoskeletal pain involve tendon impairments (Kaux et al., 2011), reaching similar prevalence to those injuries related to sports activity (Khan & Scott, 2009). However, and although the overuse factor is widely accepted to be significant, the role of inflammation in the different phases of tendinopathy is not completely understood (Rees et al., 2014). In terms of tendon management, a conservative approach shows positive effects in improving pain and function in some studies (Fournier & Rappoport, 2005; Rees et al., 2006), but the ideal treatment for tendon injuries represent a challenge and remains unclear (Skjong et al., 2012).

Kinesiotape (KT) is a therapeutic taping technique developed by Dr Kenzo Kase in Japan in the mid-1970s (Halseth et al., 2004). Research has shown that a wide variety of musculoskeletal conditions such as patellofemoral pain (Campbell & Valier, 2016; Chang et al., 2015; Kurt et al., 2016), carpal tunnel syndrome (Aktürk et al., 2018) and shoulder impingement syndrome (Hsu et al., 2009; Shih et al., 2018) may benefit from this technique. This is not only in the context of musculoskeletal disorders, as the number of clinical conditions in which KT is gaining importance is increasing, including ophthalmological (Costin, 2018), urological (Krajczy et al., 2018), vascular (Aguilar-Ferrándiz et al., 2014) and neurological conditions (Jaraczewska & Long, 2006; Kalichman et al., 2010; Unger et al., 2018). Among its actions are pain relief (Ay et al., 2017; Hazar Kanik et al., 2018; Lim et al., 2013), ROM improvement (Yoshida & Kahanov, 2007), injury prevention (Berezutsky, 2018; Hsiao-Yun Chang et al., 2018; Williams et al., 2012), muscle activity facilitation (Wong et

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al., 2012; Yeung et al., 2015) or inhibition (Abubaker & Muaidi, 2018; Davison et al., 2016), lymphatic drainage (Taradaj et al., 2014; Tsai et al., 2009), joint position sense improvement (Kurt et al., 2016), improved proprioception and kinaesthetic awareness (Bischoff et al., 2018; Hosp et al., 2015; Seo et al., 2016), and dynamic balance enhancement (Hsiao-Yun Chang et al., 2018). Typical KT micro-convolutions, which provoke a lifting of the skin over the underlying tissue, may constitute a physical-base explanation. A psychological component has also been considered with regards to the support, comfort, and security perceived by patients (Vercelli et al., 2013).

The purpose of this study was to synthesize the available evidence regarding the benefits and harms of isolated KT for the treatment of tendinopathies. Recent systematic reviews have indicated a lack of consistent evidence regarding the efficacy of KT on musculoskeletal disorders (Mostafavifar et al., 2012; Parreira et al., 2014). Understanding the effect of KT on tendinopathy may change the therapeutic approach itself. Current therapeutic tendencies for tendinopathies widely vary, ranging from eccentric exercise and manual therapy to more invasive approaches such as dry needling (Aicale et al., 2018), with most treatments essentially focusing their action on increasing blood flow to the tendon. It has been postulated that the KT lifting effect may improve blood and lymphatic flow and reduce pain by mechanically decreasing pressure on pain receptors (Lee & Yoo, 2012). Therefore, the primary goal of this review was to ascertain the impact of kinesiology tape in the affected tendon in every different way this structure elicits a deficit.

Furthermore, despite the existence of systematic reviews that assess the effect of various interventions for both generic (Andia et al., 2014; de Vos et al., 2010; Gambito et al., 2010; Lui & Ng, 2013; Sanderson & Bryant, 2015) and concrete, well-defined (Habets & van Cingel, 2015; Kearney & Costa, 2010; Larsson et al., 2012; Littlewood et al., 2012; Wilson et al., 2018) tendinopathies, some of them firstly regarding the effectiveness of isolated KT for treating distinct musculoskeletal conditions and tissues, specifically ankle (Wang et al., 2018; Wilson & Bialocerkowski, 2015) and lower back disorders (Li et al., 2018; Nelson, 2016), no previous reviews have been identified that define specifically tendinopathies as a focus for evaluation. Considering this gap in the literature, there is justification to undertake a review to assess the effectiveness of isolated KT in the management of tendinopathies.

Methods

Study protocol and registration

This systematic review was conducted and reported according to Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) recommendations (Liberati et al., 2009). The study was registered with the International Prospective Register of Systematic Reviews (PROSPERO). It was registered after a pilot search and prior to updated data search and extraction (Registration number CRD42014013832). No funding was received in the preparation of this study.

Data Sources and Search Strategy

Individualized, computer-based search strategies for PubMed, Cumulative Index to Nursing and Allied Health Literature (CINAHL), Cochrane Library, SportDiscus, and Physiotherapy Evidence Database (PEDro) were conducted in January 2018, with no restriction on the earliest date. The search strategy was based on the medical subject heading (MeSH) and non-MeSH search terms. The following keywords were used: Kinesiotap*, Kinesio Tap*, Kinesio, Kinesio-tap*, Neuromuscular Tape, and Tendinopathy. The various synonyms of KT were also combined with the terms Tendon, Tendon Injuries, Tendinitis, Tendinosis, and the following specific tendinopathies Achilles tendinopathy, Jumper's knee, Patellar tendinopathy, Epicondylitis, Medial elbow epicondylar tendinopathy, Medial epicondylitis, Rotator cuff tendinitis, Subacromial impingement syndrome, De Quervain's syndrome, and De Quervain disease. The electronic search was complemented by hand searching reference lists from previous systematic reviews and related papers. In addition, a recognized expert in this field was consulted in an attempt to identify any further published studies.

Eligibility Criteria for Selection

A PICO (population or problem, intervention, comparison, outcomes) question was established as a framework and followed during the literature selection process (Table 1). According to this, studies were included if they met the following criteria: (i) population: patients with tendinopathy; (ii) intervention: KT was applied as a treatment method comprising at least one arm in the study; (iii) comparison: between KT and placebo, control, other tapes or techniques; (iv) outcomes: all clinical outcomes were analysed, including those based on pain, function, disability, or quality of life. Exclusion criteria were reviews, meta-analyses, case reports, expert opinions, and studies using multimodal approaches or mixed/hybrid bandage techniques. Articles, editorials, and letters published in abstract form were also discarded. Studies in languages other than English were not considered during the entire search. No date restrictions were used in order to maximize information collection.

To select relevant articles, titles and abstracts of all identified citations were independently screened by two reviewers (LM-S, IM-P) applying the a priori inclusion/exclusion criteria. Agreement between the two authors regarding which articles to read in full was determined by consensus. Full-text articles were retrieved if the abstract provided insufficient information to establish eligibility or if the article had passed the first eligibility screening. The reference lists of all selected publications were screened by all reviewers to retrieve relevant publications that were not identified in the computerized search. A predesigned data extraction form was used to collect and synthesize the data. The study characteristics extracted were study design, target

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TABLE 1. PICOS format and search key words

	Definition	Search Key Words	Studies
Population (P)	Any participants	Not set	Studies that evaluated the effect of kinesiotape on clinical and functional parameters in adults of any age with tendinopathy, regardless of gender, clinical stage and type of tendinopathy.
Intervention (I)	Any form of kinesiotape in isolation	Kinesio* OR kinesiotap*	Studies that reported the effect of kinesiotape on clinical and functional parameters in adults with tendinopathy. The intervention could take place in any setting and be delivered to a group or individual participant. All types of kinesiotape application were considered for inclusion.
Comparison (C)	Any interventions	Not set	The studies that compared kinesiotape with any other intervention.
Outcome (O)	Tendinopathy Tendon disorder Tendonitis Tendinosis	(pain) OR (functional outcome)	Clinical and functional parameters accompanying tendinopathy measured by specific or patient-reported assessment tools.
Study Design (S)	Randomized and non-randomized clinical studies	Not set	Both randomized and non-randomized clinical studies

population (gender, age), sample size, type of injury, follow-up duration, interventions (detailed information about the application of KT), and all reported outcomes. Data were extracted independently by two authors (LM-S and MO-C) and confirmed by one other author (IM-P). Any discrepancies were settled by further discussion and consensus. Papers not meeting inclusion criteria and duplicates were excluded. All decisions were discussed and agreed upon by three researchers, ensuring a rigorous application of the inclusion criteria.

Methodological Quality Assessment

The risk of bias was assessed using the critical evaluation of the Physiotherapy Evidence Database (PEDro) scale (Maher et al., 2003). This tool provides credibility or internal validity evaluation, as well as determining whether the trial contains sufficient statistical information to make it interpretable. Individual reviews were discussed among researchers resolving the points of disagreement by group consensus. Studies with a PEDro score ≥5 were considered at low risk of bias and high methodological quality (Moseley et al., 2002). According to Foley et al., studies with a PEDro score of ≥ 6 represent level 1 evidence (6-8 = good; 9-10 = excellent) whereas studies scoring ≤ 5 reach level 2 evidence (4-5 = acceptable; < 4 = poor) (Foley et al., 2003).

Outcomes of interest

Pain reduction over time and measures of functional recovery were our primary outcomes of interest. Pain was measured via a visual analogue scale (VAS) in six of the 13 studies (Dilek et al., 2016; Firth et al., 2010; Göksu et al., 2016; Homayouni et al., 2013b; Homayouni et al., 2016; Thelen et al., 2008), while two of the 13 studies used the Numerical Pain Raring Scale (NPRS) (Au et al., 2017; Massei et al., 2017). Types of painful sensation assessed included load-induced pain, pressure pain threshold, tenderness, pain at rest/activity, pain at daily living activities, pain at night, and palpation-induced pain. Strength data were also obtained through maximal grip strength, maximal wrist flexor strength, pain-free grip strength, force sense, rate of loading and power (using single-hop test and counter-movement jump (CMJ) procedures) (Au et al., 2017; Chang et al., 2012; Chang et al., 2013; Dilek et al., 2016; Firth et al., 2010; Griebert et al., 2016; Massei et al., 2017). Functional improvement was addressed according to different parameters depending on the specific impairment, such as muscle activity (motion tracking, EMG activity) muscle excitability (Hoffman reflex test), ROM and pain-free ROM, along with validated patient-reported outcome reports (PROs), such as the Shoulder Pain And Disability Index (SPADI), Victorian Institute of Sports Assessment – Achilles (VISA-A), Patient Rated (Forearm) Tennis Elbow Evaluation Questionnaire (PRTEE), Nirschl score, and Star Excursion Balance Test (SEBT) (Au et al., 2017; Dilek et al., 2016; Firth et al., 2010; Göksu et al., 2016; Liu et al., 2007; Massei et al., 2017; Shakeri et al., 2013; Thelen et al., 2008).

Results

Study Identification

A database search was performed using MEDLINE, SPORT Discus, CINAHL, PEDro, and the Cochrane Library, yielding 34 citations specific to the search terms used. Among them, 26 were from Pubmed, three from CINHAL, and three from SportDiscus. Two additional studies that met the criteria for inclusion were identified by hand search and checking the reference lists of selected studies. Removal of duplicates resulted in 21 references, whereas three were excluded by language, two after discovering patients did not suffer from tendinopathy, and nine after verifying that multimodal approaches were developed. Following consensus, a review of titles and abstracts resulted in the exclusion of seven references as they did not meet the eligibility criteria. After screening the citations by title and abstract, 13 studies that used isolated KT to treat tendinopathy were finally selected in the qualitative synthesis. Figure 1 represents the PRISMA flowchart for the selection process.

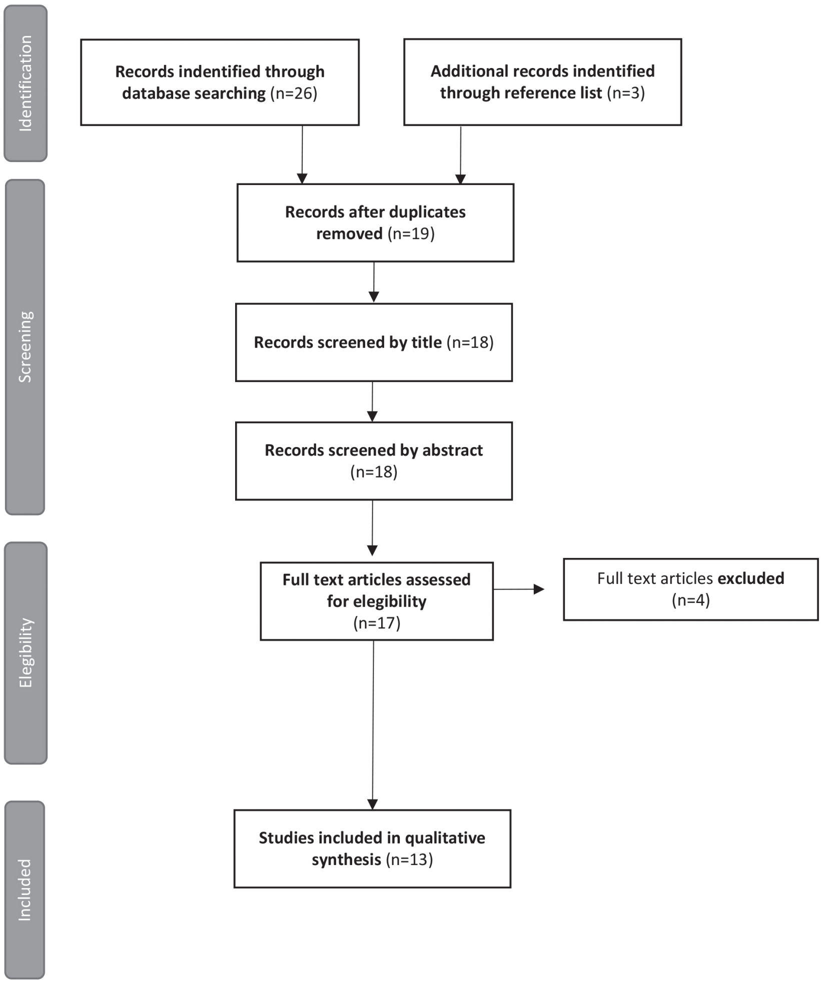

FIGURE 1. PRISMA flow diagram of search results

Study Characteristics

A total of 13 studies finally comprised this review, involving 454 participants (n=193 comparisons, n=261 interventions). Eight of them were conducted in Asia, whereas three studies were originally from North America and three from Europe. The final selection was published from 2007 to 2017. The included studies involved both athletes (n=64) and non-athletes (n=390). A summary of the included studies is presented in Table 2.

TABLE 2. Characteristics of selected studies

Authors, Year	Type of study	Sample size	Intervention groups	Type of injury	Intervention/Measures	Outcomes
Chang et al., 201371	RCT	n=27 male athletes	Healthy athletes group (n=17) and affection group (n=10)	Medial elbow tendinopathy	Three taping conditions (no tape, placebo tape and KT) in medial forearm in both groups to determine its clinical effectiveness in maximal grip strength and force sense.	No significant interactions in enhancing the overall strength and grip strength, just in absolute force sense error for KT and placebo tape.
Firth et al., 201063	NRCT	n=55 at baseline, n=48 at the end of the study	Healthy group (n=26) and affection group (n = 29). 7 subjects left the study, remaining 24 participants per group	Achilles tendinopathy	KT on the Achilles tendon in both groups to evaluate its effect on single-leg jump distance, pain and motor neuron excitability.	KT had no effects on the variables of the study.
Chang et al., 201270	Case control	n=27	Healthy athletes group (n=17) and affection group (n=10)	Medial elbow tendinopathy	Three taping conditions (no tape, placebo tape and KT) in both groups to search for immediate effects in pain, strength of wrist flexors and force sense.	No significant changes in wrist flexors strength and force sense between groups. Pressure pain significantly improved in both groups for KT and placebo tape.

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Authors, Year	Type of study	Sample size	Intervention groups	Type of injury	Intervention/Measures	Outcomes
Liu et al., 200773	Case series	n=2	Affection group (n=2)	Lateral epicondylitis	KT application to identify a potential benefit in the motion of the extensor carpi radialis muscles.	Results showed a smaller extension movement after 24 hours of KT.
Thelen et al., 200862	Prospective, randomized, double-blinded, clinical trial	n=42	Control group (n=21) and experimental group (n=21)	Rotator cuff tendinopathy/ shoulder impingement	KT application to determine short-term clinical efficacy in ROM, pain and function in comparison with sham taping.	Experimental group showed immediate significant improvements just in active shoulder abduction movement. Pain was only significant for KT at day 1.
Shakeri et al., 201374	RCT	n=30	KT group (n=15) and placebo tape control group (n=15)	Subacromial Impingement Syndrome	Investigate the effect of KT on pain intensity during movement, nocturnal pain, and pain-free shoulder ROM immediately after taping, after three days and after one week, in comparison with placebo taping.	Significant changes were found in the experimental group in pain during movement, nocturnal pain (also in control group), and pain-free ROM after KT. Immediately after KT, pain during movement and nocturnal pain changes were significantly better in the experimental group, with no differences between groups in ROM measures. No significant differences between groups were found after one week in pain intensity and shoulder ROM.
Homayouni et al., 201364	Prospective RCT	n=60	KT group (n=30) and physiotherapy group (n=30)	De Quervain's disease	KT application to assess changes in pain and swelling in comparison with physical therapy modalities (paraffin, ultrasound, TENS, friction massage).	Pain significantly improved in both groups, being more meaningful for KT group. Swelling changes were only significant in KT group.
Dilek et al., 201666	Case series	n=31	KT group (n=31)	Lateral epicondylitis	KT application to evaluate changes in pain, grip strength, disability and stage of the disease.	Significant changes were observed in all of the measured variables at 2 and 6 weeks.
Goksu et al., 201667	RCT	n=61	KT group (n=30) and local injection therapy group (n=31)	Subacromial Impingement Syndrome	KT application to observe potential changes in pain, ROM and function, in comparison with subacromial corticosteroid injection therapy.	Significant improvements were found in both groups for all of the measured variables, but results between groups were significant in favour of local injection therapy.
Griebert et al., 201672	RCT	n=40	Healthy group (n=20) and affection group (n=20)	Medial tibial stress syndrome	KT application in both groups to study possible changes in plantar pressures and rate of loading.	Significant changes in medial midfoot time-to-peak-forces in favour of healthy subjects at the beginning, not remaining immediate and 24 hours after taping, being only significant in affection group. Regarding lateral forefoot, significant within-group differences were observed between baseline and immediate application, not 24 after taping.
Homayouni et al., 201665	Comparative RCT	n=56 at baseline, n=46 at the end of the study	KT group (n=28) and naproxen/ physical therapy group (n=28). 10 subjects left the study, remaining 27 and 19 respectively	Pes anserinus tendino-bursitis	KT application to evaluate its benefits in pain and swelling, in comparison with naproxen/physical therapy.	Significant changes were observed in both groups, being more significant for KT group.
Au et al., 201768	Deceptive crossover trial	n=33 at baseline, n=30 at the end of the study	Affection group (n=33 at the beginning, n=30 at the end of the study)	Lateral epicondylitis	Four taping conditions (facilitatory KT, inhibitory KT, sham KT and no tape) to search for immediate effects in grip strength, pain and EMG activity	No significant changes in any of the measured variables were observed between taping conditions.
Massei et al., 201769	Case Series	n=10	Affection group (n=10)	Patellar tendinopathy	Four taping conditions (placebo tape, KT, leukotape and no tape) to assess immediate changes in pain, ROM, strength, power and balance	Significant changes in favour of KT were only observed in knee flexor strength and in anteromedial and posterolateral balance directions, as well as for lateral directions for KT, leukotape and placebo tape in comparison with no tape.

Note. RCT - Randomized Controlled Trial; NRCT - Non-randomized controlled trial; KT - Kinesiotape; ROM - Range of Motion; EMG - Electromyography.

The selected papers ranged from low to high quality, with an average score of 5 (range 0-9) on the PEDro scale (table 3). Three studies were considered to be of high quality (PEDro score ≥6), and ten studies were found to be of low quality (PEDro score <6). The PEDro scores for the studies in athletes and non-athletes ranged from 0 to 6 out of 10, and from 0 to 9 out of 10, respectively. In this sense, the worst-scored criterion was the blinding of the therapist, as this can not be assumed according to the intervention´s nature. Concurrently, the best-scored items were between-group comparisons, randomization when allocating, and point estimates and variability. According to Foley et al. (2003), less than half (n=5) of the included studies reached an acceptable level.

TABLE 3. PEDro Scale scores for selected studies

	PEDro Final score	Eligibility criteria specified (ítem does not score)	Random allocation	Concealed allocation	Similar groups at baseline	Blinding of subjects	Blinding of therapists	Blinding of assessors	Measure one key outcome from 85% patients	Intention-to-treat analysis	Between-group statistical comparisons*	Variability and point measurements*
Chang et al.	4/10		Yes	No	No	Yes	No	No	Yes	No	Yes	No
Firth et al.	4/10		No	No	No	Yes	No	No	Yes	No	Yes	Yes
Chang et al.	6/10		No	No	Yes	Yes	No	No	Yes	Yes	Yes	Yes
Liu et al.	0/10		No	No	No	No	No	No	No	No	No	No
Thelen et al.	9/10		Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
Shakeri et al.	8/10		Yes	No	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
Au et al.	5/10		Yes	No	No	Yes	No	Yes	No	Yes	Yes	No
Griebert et al.	2/10		No	No	Yes	No	No	No	No	No	Yes	No
Goksu et al.[67]	7/10		Yes	Yes	Yes	No	Yes	No	Yes	Yes	Yes	No
Homayouni et al.	7/10		Yes	Yes	Yes	No	No	No	Yes	Yes	Yes	Yes
Dilek et al.[66]	4/10		No	No	No	No	No	No	Yes	Yes	Yes	Yes
Homayouni et al.	5/10		Yes	No	Yes	No	Yes	No	No	Yes	Yes	No
Massei et al.	4/10		Yes	No	Yes	No	No	No	No	Yes	Yes	No

Note. * - for at least one key outcome.

Until now, three high-quality studies showed moderate significant improvement at the final follow-up measurement when compared with conventional physical therapy (Homayouni et al., 2013b; Homayouni et al., 2016), medication (Homayouni et al., 2016), or placebo taping (Shakeri et al., 2013). An indirect ROM improvement was also found in another RCT by Thelen et al. with no further changes (Thelen et al., 2008), while Griebrt et al. (2016) uniquely demonstrated an immediate biomechanical influence which tended to disappear after 24 hours. Additionally, one low-quality study corroborates such functional and clinical amelioration in terms of associated pain and grip strength (Dilek et al., 2016). Conversely, two high-quality studies showed no beneficial effect of KT for the management of tendinopathies when compared with placebo treatment (Chang et al., 2013) or corticosteroid injection (Göksu et al., 2016). Therefore, there is weak evidence that isolated KT improves pain and/or function in tendinopathies when compared with other treatment options.

Kinesiotape on Strength and Muscle properties

Strength and muscle properties were evaluated in six studies through dynamometry, functional test, electromyography (EMG), and specific software (Au et al., 2017; Chang et al., 2012; Chang et al., 2013; Dilek et al., 2016; Griebert et al., 2016; Massei et al., 2017). Assessed outcomes included maximal grip strength, pain-free grip strength, sense of related/absolute strength (both measured with a hydraulic hand dynamometer JAMAR) when assessing forearm structures, EMG activity of wrist extensors (during pain-free and maximal grip strength), rate of loading (pressure mat with a Tekscan® system), strength and power (counter-movement vertical jump procedure).

Strength in the presence of medial elbow tendinopathy was measured in two studies (Chang et al., 2012; Chang et al., 2013). Chang et al. aimed to determine the clinical effectiveness in maximal grip strength and grip force sense by the application of KT in comparison with healthy athletes (Chang et al., 2013). Three different tape dressings, including without-taping (WT), placebo KT (PKT), and KT were randomly applied with an interval of one week between measurements. In this study, significant changes among groups and taping conditions were only found in absolute force sense error ($p=0.04$), observing smaller errors for PKT and KT than WT in the experimental group ($p<0.05$). Also, WT presented larger errors than PKT in the control group. Comparing between groups, the experimental group showed smaller errors in PKT condi-

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tion ($p<0.05$). However, no significant improvements were found between groups and taping conditions for maximal grip strength and related grip force sense error ($p=0.50$ and 0.22, respectively). In another study, Chang et al. evaluated the same muscle properties (maximal grip strength and grip force sense), applying the same three taping conditions identically, in a study comparing baseball pitchers to healthy athletes (Chang et al., 2012). Results regarding maximal wrist flexor isometric strength also showed no significant difference among the three taping modalities for both healthy groups ($p=0.838$) and the medial epicondylitis group ($p=0.232$). For absolute force sense error, significant results among three taping methods for the ME group (WT > KT, $p=0.023$) were also found, not being significant for the healthy group. Regarding related force sense error, there was a significant difference for the healthy group ($p=0.036$) but not significant for the ME group ($p=0.741$).

Lateral epicondylitis was addressed in two studies (Au et al., 2017; Dilek et al., 2016). Au et al. (2017) aimed to evaluate pain-free grip strength, maximal grip strength (both of them measured using Jamar dynamometer) and EMG activity of wrist extensors during these two previous conditions. All participants went through four KT conditions (inhibitory KT, facilitatory KT, sham KT, and untaped), and were assessed immediately after each tape application. Results regarding pain-free and maximal grip strength showed no significant changes ($p=0.312$ and $p=0.499$, respectively) between different conditions. Similarly, there were no significant differences in the EMG activity measures in pain-free and maximal grip strength ($p=0.618$ and $p=0.774$, respectively). Dilek et al. (2016) focused on measuring grip strength using a Jamar dynamometer, and KT was applied twice a week for two weeks. Evaluations were carried out before treatment, at two weeks and six weeks after intervention. Results showed significant improvement ($p<0.05$) in handgrip scores at two and six weeks. Specifically, the handgrip strength of the affected side reached 67.5% of the unaffected side.

One study assessed KT and its effect in the presence of MTSS (Griebert et al., 2016). KT effects regarding the rate of loading and plantar pressure were evaluated in comparison with healthy subjects. A Tekscan® pressure mat system was used to calculate time-to-peak forces (TTPF) in each previously-divided area of the foot, including lateral forefoot (LFF), lateral midfoot (LMF), lateral rearfoot (LRF), medial forefoot (MFF), medial midfoot (MMF) and medial rearfoot (MRF). Measures were taken before (baseline), during (KT-1) and 24 hours (KT-2) after KT application. Outcomes showed significant TTPF differences at the MMF in favour of healthy participants at baseline ($p=0.021$), but not in KT-1 nor KT-2 applications, where these changes were only significant in the MTSS group ($p=0.022$ and $p=0.043$ respectively). Moreover, the MTSS group also showed significant within-group differences between baseline and KT-1 under the LFF ($p=0.031$), not remaining at KT-2 ($p=0.29$).

KT effects on patellar tendinopathy were analysed in one study by Massei et al. (Massei et al., 2017), in which four different tape conditions such as no tape (NT) as baseline session, placebo tape (PT), KT, and Leukotape (LT) were applied. Power and strength were measured using the counter-movement vertical jump procedure and electronic, hydraulic push-pull dynamometer, respectively. All subjects went through all four taping conditions, committing to four testing sessions with at least one day of rest between them. Results showed no significant changes regarding power between different taping conditions. However, significant improvements were observed in knee flexor strength when comparing KT with LT, NT and PT ($p<0.05$), but not regarding knee extensor strength, where no meaningful effect was found between taping conditions.

Kinesiotape on Joint Function

Functionality was assessed with several procedures in seven studies (Dilek et al., 2016; Firth et al., 2010; Göksu et al., 2016; Liu et al., 2007; Massei et al., 2017; Shakeri et al., 2013; Thelen et al., 2008), including the Shoulder Pain And Disability Index (SPADI), single hop test, Victorian Institute of Sports Assessment – Achilles (VISA-A), Patient Rated (Forearm) Tennis Elbow Evaluation (PRTEE), Nirschl score, and Star Excursion Balance Test (SEBT). Moreover, range of motion (ROM) variables were measured by goniometry in 4 studies(Göksu et al., 2016; Massei et al., 2017; Shakeri et al., 2013; Thelen et al., 2008), and neuron excitability was measured in one study (Firth et al., 2010). Additionally, one study comprised muscular motion tracking by ultrasonography (Liu et al., 2007).

Shoulder impingement was evaluated in three studies (Göksu et al., 2016; Shakeri et al., 2013; Thelen et al., 2008). Thelen et al. (2008) aimed to assess disability (SPADI) and pain-free ROM after KT application in comparison with sham taping. Subjects were randomly allocated in KT and sham KT groups. Measures were obtained at baseline, right after taping (except SPADI score), three and six days after the initial application, re-taping subjects on the third day after being inspected and assessed. Significant changes were found in all outcomes on the sixth-day follow-up, but none of them, apart from shoulder abduction at the first day ($p=0.005$), were more efficacious than sham taping (Thelen et al., 2008). Shakeri et al. studied the effect of KT on pain-free active shoulder ROM (abduction, flexion and scapular elevation) in comparison with placebo taping. Subjects were randomly allocated in KT and placebo KT groups, and measures were obtained at baseline, immediately after taping, three days and one week after initial application, re-taping subjects at fourth day after skin evaluation. Results showed significant improvements in all measures for both groups (except for shoulder flexion in the control group), but differences were not meaningful between them (Shakeri et al., 2013). Goksu et al. compared the effect of KT and local injection therapy. KT was applied three times at three-day intervals. Functionality was measured in terms of active flexion, abduction, internal and external rotation

ROM goniometry and SPADI score, obtaining results at baseline, one week and four weeks after therapy. Both groups showed significant changes in all outcomes at the first and fourth weeks ($p<0.05$). When comparing between-group results, only abduction ROM and SPADI scores were significantly relevant for the local injection group ($p<0.05$) (Göksu et al., 2016).

One study assessed KT and its effect in the presence of Achilles tendinopathy (Firth et al., 2010). Firth et al. investigated the effect of short-term KT in comparison with healthy people. Jumping distance and neuron excitability were measured using a single hop test and evoking Hoffman reflex (of the soleus and gastrocnemius muscles), respectively. VISA-A score in the Achilles tendinopathy group revealed a wide range of disability levels among participants, ranging from 21 to 94. Measurements were taken before the application of the band, during and after its disposal. Results showed no significant differences in the jumping distance when applying the bandage in both groups ($p=0.55$), and, as expected, the affected group did not jump as far as the healthy group did ($p<0.0005$). The Hoffman reflex amplitude in the soleus and gastrocnemius increased in the healthy group after removal ($p=0.01$ and $p=0.03$, respectively), while it remained unchanged in people with Achilles tendinopathy ($p=0.43$ and $p=0.16$, respectively) (Firth et al., 2010).

Two studies evaluated KT and its effect in the presence of lateral epicondylitis (Dilek et al., 2016; Liu et al., 2007). Dilek et al. (2016) assessed disability and the stage of the disease by using PRTEQ function subscales and Nirschl score, respectively. KT was applied twice a week for two weeks, and evaluations were done at baseline, at two and six weeks after treatment. Results showed significant changes for all outcomes at two and six weeks ($p<0.05$). Liu et al. (2007) studied two volunteers with lateral epicondylitis. Subjects performed both passive and active wrist flexion-extension for periods of two seconds, with and without KT. Motion tracking of the extensor carpi radialis muscles, in terms of longitudinal scans in proximal and distal areas of the lateral epicondyle, were recorded using dynamic ultrasound imaging. These experimental results showed a smaller extension movement after 24 hours of KT than before taping.

Massei et al. (2007) investigated KT effects in the presence of patellar tendinopathy. Knee ROM and dynamic balance were assessed by using a standard goniometer and SEBT score, respectively. Knee ROM measures were taken in the supine position, and SEBT information was obtained based on anterior, anterolateral, anteromedial, posteromedial posterior, posterolateral, medial, and lateral dynamic balance. All subjects received all four taping conditions, divided over four days with at least one day rest in between them. No significant changes in ROM were observed for knee flexion and extension. Regarding dynamic balance, a significant effect was found in anteromedial, lateral and posterolateral directions between taping conditions ($p<0.05$). Reach distances were greater for KT in anteromedial and posterolateral directions ($p<0.05$); as for lateral directions, significant changes were observed between KT, LT, and PT in comparison with NT ($p<0.05$).

Kinesiotape on Pain

Pain sensation was measured using different evaluation procedures in a total of 10 studies(Au et al., 2017; Chang et al., 2012; Dilek et al., 2016; Firth et al., 2010; Göksu et al., 2016; Homayouni et al., 2013b; Homayouni et al., 2016; Massei et al., 2017; Shakeri et al., 2013; Thelen et al., 2008), nine of them using validated scores such as the Visual Analogic Scale (VAS), Numeric Pain Rating Scale (NPRS), SPADI and PRTEQ (Au et al., 2017; Dilek et al., 2016; Firth et al., 2010; Göksu et al., 2016; Homayouni et al., 2013b; Homayouni et al., 2016; Massei et al., 2017; Shakeri et al., 2013; Thelen et al., 2008). Additionally, algometry was employed in one of the studies (Chang et al., 2012).

Shoulder pain was evaluated in three studies (Göksu et al., 2016; Hassan Shakeri et al., 2013; Thelen et al., 2008). Thelen et al. assessed the short-term effects of KT, using SPADI and VAS scores (Thelen et al., 2008). Subjects were randomly allocated in a therapeutic KT group and a sham KT group, and all measures were taken at baseline, immediately after taping (except SPADI score), three days and six days after tape application. Results showed significant changes within each group, but no between-group differences existed except for VAS on Day 1, which was significantly better for the KT group ($p=0.01$). Shakeri et al. evaluated the short-term effects of KT in comparison with placebo taping (Shakeri et al., 2013). Pain intensity during movement and nocturnal pain were assessed using the VAS scale, and measures were obtained at baseline, immediately after taping, as well as three days and one week after initial application. Significant changes in pain during movement (for KT group) and in nocturnal pain (for both groups) were found; however, they were only significantly greater for the KT group immediately after the initial application; those significant differences did not remain at the end of the study. Goksu et al. (2016) assessed pain in individuals with subacromial impingement syndrome in comparison with local injection therapy, applying KT three times over a three-day interval. Pain at rest and movement was assessed by using 100-mm VAS and SPADI scores, obtaining results at baseline, as well as one week and four weeks after therapy. Significant improvements were found at one and four weeks after treatment in both rest and movement pain variables for both groups ($p<0.05$), but only VAS pain at rest and the SPADI score were significant between groups in favour of the local injection therapy group ($p<0.05$).

Achilles tendinopathy was assessed in one study. Firth et al. evaluated the effect of KT on pain in comparison with healthy subjects (Firth et al., 2010). A 10-cm VAS score was used to determine the level of pain before tape application, with the tape in place and after tape removal. In addition, pain during a single-hop test was also recorded with and without tape. No significant changes were found in VAS scores by the application of

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this tape nor during the hop test with and without tape (p=0.74) (Firth et al., 2010).

Pain in medial elbow tendinopathy was measured only in one study, dealing with baseball pitchers suffering from tendinopathy and comparing them to healthy athletes (Chang et al., 2012). An algometer and a VAS score were used to measure the pressure pain threshold (PPT) and 4-kg pressure pain tolerance, both in the muscle belly and muscle-tendon junction of the common wrist flexors locations. Three taping conditions (no-taping, placebo taping and KT) were applied to each participant with an interval of one week. Results revealed significant changes in PPT and 4-kg pressure pain tolerance in favour of placebo and KT compared to no-taping for both the healthy and affected groups (p<0.05).

Homayouni et al. measured the effect of KT on pain in those with pes anserinus tendino-bursitis. They compared KT application with nonsteroidal anti-inflammatory drugs and physical therapy (Homayouni et al., 2016). Pain and swelling scores were recorded using VAS and soft tissue sonography. KT was applied three times for three weeks, with a one-week interval, assessing different scores at baseline and after treatment. Results showed significant changes in both groups after interventions for all outcomes (p=0.0001), but KT was significantly more effective for decreasing pain and swelling scores (p=0.0001).

Lateral epicondylitis was analysed in two studies by Au et al. (2017) and Dilek et al. (2016). The first study addressed pain after applying the following four KT conditions in every patient (inhibitory KT, facilitatory KT, sham KT and untaped) (Au et al., 2017). Similar to grip strength, pain was assessed immediately after each tape application, and an NPRS scale was employed. Pain intensity information was collected during the maximal grip strength test. Results also showed no significant differences in pain intensity among taping conditions (p=0.321). In the second study, KT was applied twice a week over a two-week period, measuring pain at rest, during of daily living activities, night and palpation on lateral epicondyle (Dilek et al., 2016). The VAS and PRTEQ scales were used at baseline, at two and six weeks after treatment. Significant improvements were observed in all parameters at two and six weeks for both VAS and PRTEQ scores (p<0.001).

De Quervain's disease was assessed in one paper in which KT effects on pain in comparison with physical therapy were studied (Homayouni et al., 2013a). Pain and the presence of swelling were measured using a 100-mm VAS score and physician inspection-palpation. KT was applied four times a week, and scores were recorded at baseline and one month after treatment. A significant decrease in VAS was observed at the end of the treatment in both groups (p< 0.001), being more meaningful in the KT group. Swelling changes were significant in the KT group (p<0.001) but not in the PT group (p>0.05), showing significantly better results for KT in comparison with PT.

Lastly, the study by Massei et al. (2017) was the only one focusing on patellar tendinopathy. This investigation evaluated pain after the application of four different tape conditions, comprising NT, PT, LT, and KT. These taping modalities were applied to all the participants in four different sessions. An NPRS score was employed to assess pain, recording pre- and post-treatment measures. Results from ANOVA showed no significant effects for time or taping condition.

Discussion

The theory about the benefits of KT in treating such a wide variety of conditions argues that its properties reduce recovery times due to several effects, such as decreasing pain, improving muscle and joint function, lymphatic circulation and, subsequently, microcirculation and inflammation (Halseth et al., 2004). The purpose of this systematic review was to investigate whether existing evidence supports the implementation of KT dressing technique in patients with tendinopathy. The findings provided conflicting evidence regarding the effectiveness of KT for the treatment of tendinopathies.

This review included 13 studies investigating the effects of kinesiotape for tendinopathies affecting diverse anatomical regions. Of the 13 studies, nine presented upper extremity tendinopathies, and four presented lower extremity tendinopathies. Studies reporting benefits (n=7) were greater in number to those that found no benefit or no significant changes (n=6) (Au et al., 2017; Chang et al., 2012; Chang et al., 2013; Firth et al., 2010; Liu et al., 2007; Massei et al., 2017). However, it is important to note that these improvements were not present at longer-term follow up, did not imply a clinical change in every case, and did not always arise from high-quality research. These results may not be due to methodological quality, however; the studies' methodological scores were generally inadequate, with less than half of the included studies (n=5)(Hsiao-Yun Chang et al., 2012; Göksu et al., 2016; Homayouni et al., 2013a; Shakeri et al., 2013; Thelen et al., 2008) scoring six or more points on the PEDro scale. Blinding of subjects, therapists, and evaluators were not generally achieved, with just two studies accomplishing, at least, two of these items (Au et al., 2017; Thelen et al., 2008) and six studies not fulfilling any of them (Dilek et al., 2016; Griebert et al., 2016; Homayouni et al., 2013b; Liu et al., 2007; Massei et al., 2017; Shakeri et al., 2013). Baseline group characteristics were similar in most of included the studies. Chang et al. (2013) presented no baseline data. The control group of Firth et al. (2010) differed in subjects' age and sex, while three studies just included a single experimental group (Au et al., 2017; Dilek et al., 2016; Griebert et al., 2016).

Regarding direction (origin-insertion theory), time and tensional percentage of the application, there is a lack of agreement in the reviewed literature. Most of the studies followed the "insertion to origin" fashion according to the inhibitory theory so as to stretch the Golgi tendon organ at the distal end of the target muscle, though Griebert et al. (2016) chose to apply from origin to insertion also obtaining consistent results for KT group. Moreover, Au et al. (2017) dealt with both application strategies and showed no significant differences between them, thus refuting the proposed mechanisms suggested by Kase (Halseth et al., 2004), but also noting that two circular holes were cut to allow for EMG electrode placement, which could affect the structure of the tape and subsequently the results. Time of application also differed among studies, varying from immediate application (Au et al., 2017; Firth et al., 2010; Massei et al., 2017), one day (Griebert et al., 2016) and two to three days (Shakeri et al., 2013). Uneven frequencies were also observed, ranging from daily to weekly, by way of two three-day intervals. Although similar designs were found for each type of injury, the stretching percentage of the band was inconsistent between studies, largely relying on the experience of the therapist. There was only one study where stretch tension was standardized, measuring the distance between the line 2 cm distal to the medial epicondyle of the humerus and the wrist joint line, and then multiplying by 0.8 to set the final length of the band (Chang et al., 2012). However, there was concordance in terms of the follow-up period, mostly lasting less than three weeks, with just three studies evaluating at the fourth week (Göksu et al., 2016; Homayouni et al., 2013a) and sixth week (Dilek et al., 2016).

The previous condition of the patient might have been a determinant for the final results in some studies. For instance, Thelen et al. (2008) allowed prescribed nonsteroidal anti-inflammatory drugs (NSAIDs) intakes prior to research enrolment. Massei et al. (2017) included active individuals (around 150 minutes of moderate to vigorous activity per week), and Goksu et al. (2016) provided guidelines for a home exercise programme, possibly ensuring prolonged pattern corrections which integrate properly with the therapy (Khan et al., 2013).

The KT lifting function over skin is proposed to relieve pressure on nociceptors immediately, thus directly reducing the perceived pain (Halseth et al., 2004). Generally, improvements in pain reduction were found among different studies (Chang et al., 2012; Dilek et al., 2016; Göksu et al., 2016; Homayouni et al., 2013b; Homayouni et al., 2016; Shakeri et al., 2013; Thelen et al., 2008), but its superiority against sham taping or other forms of treatment is not supported. One study found significantly better changes in favour of local injection therapy (Göksu et al., 2016), and six, despite observing significant intra-group changes, showed no significant differences in most of the different variables between sham taping (Au et al., 2017; Chang et al., 2012; Shakeri et al., 2013; Thelen et al., 2008), other taping conditions (Massei et al., 2017) or comparing to healthy subjects(Firth et al., 2010). However, Homayuni et al. (2013a; 2016) observed greater changes for KT in comparison to physical therapy alone and with nonsteroidal anti-inflammatory drugs. Similar results in favour of KT were also found by Dilek et al. (2016), although no comparison group was employed. Interestingly, Thelen (2008) reported no immediate differences between sham taping and KT, indicating that sham application provided a neutral effect as desired.

There is a general agreement on the gate control theory as one plausible explanation for this pain reduction, proposing that tape could stimulate neuromuscular pathways via increased afferent feedback (Kneeshaw, 2002), bringing different impacts to pain receptors and proprioceptors. This increased afferent stimulus to large-diameter nerve fibres, thus mitigating the nociceptive input activity from small-diameter fibres, might have alleviated pain-related symptoms.

Regarding muscle properties, miscellaneous findings can be observed in the literature. Strength improvements due to KT were not superior against other forms of taping (Au et al., 2017; Chang et al., 2012; Chang et al., 2013) or healthy subjects (Chang et al., 2013). Au et al. (2017) conducted all the tests in a single session, with just five minutes of rest between each taping condition, which could have led to muscle fatigue and alteration of the results. Massei et al. (2017) found no significant changes in power between taping conditions revealing, however, an increasing effect in knee flexor strength. It has been reported that the presence of swelling or oedema within the knee joint may inhibit muscular strength (Spencer et al., 1984). A possible anti-inflammatory KT effect, in addition to observed clinical changes in pain, could have influenced these results. Griebert et al. (2016) found significant immediate improvements in medial midfoot and lateral forefoot load forces in patients with MTSS following the immediate application of KT in the first hours. It seems noteworthy that loading capacity was better in the healthy group at baseline, supporting the presence of biomechanical differences among patients and the possible corrective effect following the application of the tape. However, a single experimental-group design was carried out in three of the mentioned studies (Au et al., 2017; Dilek et al., 2016; Massei et al., 2017), which could complicate the process of contextualizing and interpreting the results.

In terms of functionality, KT effects are not generally greater than other forms of treatment. Despite showing significant changes in different variables, most of them were not superior to sham tape (Shakeri et al., 2013; Thelen et al., 2008), other taping conditions (Massei et al., 2017), or local injection therapy (Göksu et al., 2016), showing this invasive modality better results in terms of shoulder abduction and SPADI scores. Firth et al. (2010) found significant increases in the Hoffman reflex excitability only in healthy subjects, and three studies (Au et al., 2017; Dilek et al., 2016; Griebert et al., 2016) did not include a control group, making the gathering of comparative information impossible to accomplish. However, Thelen et al. (2008) and Shakeri et al. (2013) reported immediate meaningful differences in shoulder abduction ROM in KT group, clinically consistent with previous reports circumscribing these positive effects to musculoskeletal shoulder pain at the short-term, although in combination with a home exercise programme (Kaya et al., 2011). One study (Liu et

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al., 2007) proposed a new dynamic ultrasound motion tracking algorithm for the extensor carpi radialis muscles in subjects with lateral epicondylitis, showing that movement after 24 hours of KT is smaller than before taping, which could apparently correlate with the assumed constriction effect of the tape.

Synthesis of the evidence proved difficult for several reasons. The methodological quality of the studies selected was poor. The main limitation of the present review is the low quality of the included studies, limiting clinical decisions based on strong evidence. Poor blinding procedures, lack of randomization, and lack of intention to treat analysis may have weakened the scientific merit of the reviewed papers due to increased potential biases. Additionally, the studies presented small sample sizes and very heterogeneous characteristics regarding age and clinical status, which may interfere with the validity of data. Clinical application of KT was either poorly reported or varied between studies, even when managing the same condition.

Conclusion

This systematic review identified thirteen studies reporting on the effectiveness of KT for treatment of tendinopathies and found that there is limited evidence to support KT for the treatment of these pathologies, especially for anything beyond the short-term. Only a small proportion of the included studies were randomized controlled trials showing real benefits, with other employing observational designs using relatively small sample sizes and no control group. In addition, improvements related to KT were not generally greater in comparison with other treatment modalities. Further research with rigorous methodological approaches, assuming more homogeneous and larger samples, thus reinforcing external validity and the generalization of the results, is needed to support the use of KT for tendinopathies.

References

Abubaker, A. A., & Muaidi, Q. I. (2018). The Effect of the Inhibition Technique of the Kinesio Taping on the Triceps Surae Muscle after an Isokinetic Fatigue Protocol. *MOJ Orthopedics & Rheumatology*, 10(1), 00384.

Aguilar-Ferrándiz, M. E., Castro-Sánchez, A. M., Matarán-Peñarrocha, G. A., Guisado-Barrilao, R., García-Ríos, M. C., & Moreno-Lorenzo, C. (2014). A randomised controlled trial of a mixed Kinesio taping-compression technique on venous symptoms, pain, peripheral venous flow, clinical severity and overall health status in postmenopausal women with chronic venous insufficiency. *Clinical Rehabilitation*, 28(1), 69-81. doi: 10.1177/0269215512469120

Aicale, R., Tarantino, D., & Maffulli, N. (2018). Overuse injuries in sport: A comprehensive overview. *Journal of Orthopaedic Surgery and Research*, 13. doi: 10.1186/s13018-018-1017-5

Aktürk, S., Büyükavcı, R., Aslan, Ö., & Ersoy, Y. (2018). Comparison of splinting and Kinesio taping in the treatment of carpal tunnel syndrome: A prospective randomised study. *Clinical Rheumatology*, 37(9), 2465-2469. doi: 10.1007/s10067-018-4176-1

Andia, I., Latorre, P. M., Gomez, M. C., Burgos-Alonso, N., Abate, M., & Maffulli, N. (2014). Platelet-rich plasma in the conservative treatment of painful tendinopathy: A systematic review and meta-analysis of controlled studies. *British Medical Bulletin*, 110(1), 99-115. doi: 10.1093/bmb/ldu007

Au, I. P. H., Fan, P. C. P., Lee, W. Y., Leong, M. W., Tang, O. Y., An, W. W., & Cheung, R. T. (2017). Effects of Kinesio tape in individuals with lateral epicondylitis: A deceptive crossover trial. *Physiotherapy Theory and Practice*, 33(12), 914-919. doi: 10.1080/09593985.2017.1359871

Ay, S., Konak, H. E., Evcik, D., & Kibar, S. (2017). The effectiveness of Kinesio Taping on pain and disability in cervical myofascial pain syndrome. *Revista Brasileira De Reumatologia*, 57(2), 93-99. doi: 10.1016/j.rbre.2016.03.012

Berezutsky, V. (2018). Possibilities of kinesio taping to prevent injuries of professional dancers. *International Journal of Occupational Safety and Ergonomics: JOSE*, 1-8. doi: 10.1080/10803548.2018.1433281

Bischoff, L., Babisch, C., Babisch, J., Layher, F., Sander, K., Matziolis, G., Pietsch, S., & Röhner, E. (2018). Effects on proprioception by Kinesio taping of the knee after anterior cruciate ligament rupture. *European Journal of Orthopaedic Surgery & Traumatology: Orthopedie Traumatologie*, 28(6), 1157-1164. doi: 10.1007/s00590-018-2167-1

Campbell, S. A., & Valier, A. R. (2016). The Effect of Kinesio Taping on Anterior Knee Pain Consistent With Patellofemoral Pain Syndrome: A Critically Appraised Topic. *Journal of Sport Rehabilitation*, 25(3), 288-293. doi: 10-1123/jsr.2014-0278

Chang, Hsiao-Yun, Huang, Y.-H., Cheng, S.-C., Yeh, C.-Y., & Wang, C.-H. (2018). Prophylactic Kinesio taping enhances balance for healthy collegiate players. *The Journal of Sports Medicine and Physical Fitness*, 58(5), 651-658. doi: 10.23736/S0022-4707.17.06955-9

Chang, Hsiao-Yun, Wang, C.-H., Chou, K.-Y., & Cheng, S.-C. (2012). Could forearm Kinesio Taping improve strength, force sense, and pain in baseball pitchers with medial epicondylitis? *Clinical Journal of Sport Medicine: Official Journal of the Canadian Academy of Sport Medicine*, 22(4), 327-333. doi: 10.1097/JSM.0b013e318254d7cd

Chang, H.-Y., Cheng, S.-C., Lin, C.-C., Chou, K.-Y., Gan, S.-M., & Wang, C.-H. (2013). The effectiveness of kinesio taping for athletes with medial elbow epicondylar tendinopathy. *International Journal of Sports Medicine*, 34(11), 1003-1006. doi: 10.1055/s-0033-1333747

Chang, W.-D., Chen, F.-C., Lee, C.-L., Lin, H.-Y., & Lai, P.-T. (2015). Effects of Kinesio Taping versus McConnell Taping for Patellofemoral Pain Syndrome: A Systematic Review and Meta-Analysis. *Evidence-*

Based Complementary and Alternative Medicine: ECAM, 2015, 471208. doi: 10.1155/2015/471208

Costin, B. R. (2018). Kinesio Tape for Treatment of Lower Eyelid Festoons. *Ophthalmic Plastic and Reconstructive Surgery*, 34(6), 602. doi: 10.1097/IOP.0000000000001242

Davison, E. A., Anderson, C. T., Ponist, B. H., Werner, D. M., Jacobs, M. E., Thompson, A. J., & Cook, M. R. (2016). Inhibitory Effect of the Kinesio Taping® Method on the Gastrocnemius Muscle. *American Journal of Sports Science and Medicine*, 4(2), 33-38. doi: 10.12691/ajssm-4-2-2

de Vos, R. J., van Veldhoven, P. L. J., Moen, M. H., Weir, A., Tol, J. L., & Maffulli, N. (2010). Autologous growth factor injections in chronic tendinopathy: A systematic review. *British Medical Bulletin*, 95, 63-77. doi: 10.1093/bmb/ldq006

Dilek, B., Batmaz, I., Sarıyıldız, M. A., Sahin, E., Ilter, L., Gulbahar, S., Cevik, R., & Nas, K. (2016). Kinesio taping in patients with lateral epicondylitis. Journal of Back and Musculoskeletal Rehabilitation, 29(4), 853-858. doi: 10.3233/BMR-160701

Docheva, D., Müller, S. A., Majewski, M., & Evans, C. H. (2015). Biologics for tendon repair. *Advanced Drug Delivery Reviews*, 84, 222-239. doi: 10.1016/j.addr.2014.11.015

Firth, B. L., Dingley, P., Davies, E. R., Lewis, J. S., & Alexander, C. M. (2010). The effect of kinesiotape on function, pain, and motoneuronal excitability in healthy people and people with Achilles tendinopathy. *Clinical Journal of Sport Medicine: Official Journal of the Canadian Academy of Sport Medicine*, 20(6), 416-421. doi: 10.1097/JSM.0b013e3181f479b0

Foley, N. C., Teasell, R. W., Bhogal, S. K., & Speechley, M. R. (2003). Stroke Rehabilitation Evidence-Based Review: Methodology. *Topics in Stroke Rehabilitation*, 10(1), 1-7.

Fournier, P. E., & Rappoport, G. (2005). [Tendinopathy: Physiopathology and conservative treatment]. *Revue Medicale Suisse*, 1(28), 1840-1842, 1845-1846.

Gambito, E. D., Gonzalez-Suarez, C. B., Oquiñena, T. I., & Agbayani, R. B. (2010). Evidence on the effectiveness of topical nitroglycerin in the treatment of tendinopathies: A systematic review and meta-analysis. *Archives of Physical Medicine and Rehabilitation*, 91(8), 1291-1305. doi: 10.1016/j.apmr.2010.02.008

Göksu, H., Tuncay, F., & Borman, P. (2016). The comparative efficacy of kinesio taping and local injection therapy in patients with subacromial impingement syndrome. *Acta Orthopaedica Et Traumatologica Turcica*, 50(5), 483-488. doi: 10.1016/j.aott.2016.08.015

Griebert, M. C., Needle, A. R., McConnell, J., & Kaminski, T. W. (2016). Lower-leg Kinesio tape reduces rate of loading in participants with medial tibial stress syndrome. *Physical Therapy in Sport: Official Journal of the Association of Chartered Physiotherapists in Sports Medicine*, 18, 62-67. doi: 10.1016/j.ptsp.2014.01.001

Habets, B., & van Cingel, R. E. H. (2015). Eccentric exercise training in chronic mid-portion Achilles tendinopathy: A systematic review on different protocols. *Scandinavian Journal of Medicine & Science in Sports*, 25(1), 3-15. doi: 10.1111/sms.12208

Halseth, T., McChesney, J. W., Debeliso, M., Vaughn, R., & Lien, J. (2004). The effects of kinesio™ taping on proprioception at the ankle. *Journal of Sports Science & Medicine*, 3(1), 1-7.

Hazar Kanik, Z., Citaker, S., Demirtas, C. Y., Bukan, N. C., Celik, B., & Gunaydin, G. (2018). Effects of Kinesio-Taping on the Relief of Delayed Onset Muscle Soreness: A Randomised, Placebo-Controlled Trial. *Journal of Sport Rehabilitation*, 1-22. doi: 10.1123/jsr.2018-0040

Homayouni, K., Zeynali, L., & Mianehsaz, E. (2013a). Comparison between kinesio taping and physiotherapy in the treatment of De Quervain´s Disease. J Musculoskelet Res, 16(4), 169.

Homayouni, K., Zeynali, L., & Mianehsaz, E. (2013b). Comparison between Kinesio taping and physiotherapy in the treatment of De Quervain's disease. *Journal of Musculoskeletal Research*, 16(4), 1350019.

Homayouni, Kaynoosh, Foruzi, S., & Kalhori, F. (2016). Effects of kinesiotaping versus nonsteroidal anti-inflammatory drugs and physical therapy for treatment of pes anserinus tendino-bursitis: A randomised comparative clinical trial. *The Physician and Sportsmedicine*, 44(3), 252-256. doi: 10.1080/00913847.2016.1199251

Hosp, S., Bottoni, G., Heinrich, D., Kofler, P., Hasler, M., & Nachbauer, W. (2015). A pilot study of the effect of Kinesiology tape on knee proprioception after physical activity in healthy women. *Journal of Science and Medicine in Sport*, 18(6), 709-713. doi: 10.1016/j.jsams.2014.09.004

Hsu, Y.-H., Chen, W.-Y., Lin, H.-C., Wang, W. T. J., & Shih, Y.-F. (2009). The effects of taping on scapular kinematics and muscle performance in baseball players with shoulder impingement syndrome. *Journal of Electromyography and Kinesiology: Official Journal of the International Society of Electrophysiological Kinesiology*, 19(6), 1092-1099. doi: 10.1016/j.jelekin.2008.11.003

Jaraczewska, E., & Long, C. (2006). Kinesio taping in stroke: Improving functional use of the upper extremity in hemiplegia. *Topics in Stroke Rehabilitation*, 13(3), 31-42. doi: 10.1310/33KA-XYE3-QWJB-WGT6

Kalichman, L., Vered, E., & Volchek, L. (2010). Relieving symptoms of meralgia paresthetica using Kinesio taping: A pilot study. *Archives of Physical Medicine and Rehabilitation*, 91(7), 1137-1139. doi: 10.1016/j.apmr.2010.03.013

Kaux, J.-F., Forthomme, B., Goff, C. L., Crielaard, J.-M., & Croisier, J.-L. (2011). Current opinions on tendinopathy. *Journal of Sports Science & Medicine*, 10(2), 238-253.

Kaya, E., Zinnuroglu, M., & Tugcu, I. (2011). Kinesio taping compared to physical therapy modalities for the treatment of shoulder impingement syndrome. *Clinical Rheumatology*, 30(2), 201-207. doi: 10.1007/s10067-010-1475-6

Kearney, R., & Costa, M. L. (2010). Insertional achilles tendinopathy management: A systematic review. *Foot*

& Ankle International / American Orthopaedic Foot and Ankle Society [and] Swiss Foot and Ankle Society, 31(8), 689-694. doi: 10.3113/FAI.2010.0689

Khan, K. M., & Scott, A. (2009). Mechanotherapy: How physical therapists' prescription of exercise promotes tissue repair. *British Journal of Sports Medicine*, 43(4), 247-252. doi: 10.1136/bjsm.2008.054239

Khan, Y., Nagy, M. T., Malal, J., & Waseem, M. (2013). The painful shoulder: Shoulder impingement syndrome. *The Open Orthopaedics Journal*, 7, 347-351. doi: 10.2174/1874325001307010347

Kneeshaw, D. (2002). Shoulder taping in the clinical setting. J Bodywork Move Ther, 6(1), 2-8.

Krajczy, M., Luniewski, J., Bogacz, K., & Szczegielniak, J. (2018). Evaluation of applying Kinesio taping in children with urinary incontinence. *Journal of Pediatric Urology*. doi: 10.1016/j.jpurol.2018.06.013

Kurt, E. E., Büyükturan, Ö., Erdem, H. R., Tuncay, F., & Sezgin, H. (2016). Short-term effects of kinesio tape on joint position sense, isokinetic measurements, and clinical parameters in patellofemoral pain syndrome. *Journal of Physical Therapy Science*, 28(7), 2034-2040. doi: 10.1589/jpts.28.2034

Larsson, M. E. H., Käll, I., & Nilsson-Helander, K. (2012). Treatment of patellar tendinopathy—A systematic review of randomised controlled trials. *Knee Surgery, Sports Traumatology, Arthroscopy: Official Journal of the ESSKA*, 20(8), 1632-1646. doi: 10.1007/s00167-011-1825-1

Lee, J., & Yoo, W. (2012). Treatment of chronic Achilles tendon pain by Kinesio taping in an amateur badminton player. *Physical Therapy in Sport: Official Journal of the Association of Chartered Physiotherapists in Sports Medicine*, 13(2), 115-119. doi: 10.1016/j.ptsp.2011.07.002

Li, Y., Yin, Y., Jia, G., Chen, H., Yu, L., & Wu, D. (2018). Effects of kinesiotape on pain and disability in individuals with chronic low back pain: A systematic review and meta-analysis of randomised controlled trials. *Clinical Rehabilitation*, 269215518817804. doi: 10.1177/0269215518817804

Liberati, A., Altman, D. G., Tetzlaff, J., Mulrow, C., Gøtzsche, P. C., Ioannidis, J. P. A., Clarke, M., Devereaux, P. J., Kleijnen, J., & Moher, D. (2009). The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: Explanation and elaboration. *Journal of Clinical Epidemiology*, 62(10), e1-34. doi: 10.1016/j.jclinepi.2009.06.006

Lim, C., Park, Y., & Bae, Y. (2013). The effect of the kinesio taping and spiral taping on menstrual pain and premenstrual syndrome. *Journal of Physical Therapy Science*, 25(7), 761-764. doi: 10.1589/jpts.25.761

Littlewood, C., Ashton, J., Chance-Larsen, K., May, S., & Sturrock, B. (2012). Exercise for rotator cuff tendinopathy: A systematic review. *Physiotherapy*, 98(2), 101-109. doi: 10.1016/j.physio.2011.08.002

Liu, Y.-H., Chen, S.-M., Lin, C.-Y., Huang, C.-I., & Sun, Y.-N. (2007). Motion tracking on elbow tissue from ultrasonic image sequence for patients with lateral epicondylitis. Conference Proceedings: ... Annual International Conference of the IEEE Engineering in Medicine and Biology Society. IEEE Engineering in Medicine and Biology Society. Annual Conference, 2007, 95-98. doi: 10.1109/IEMBS.2007.4352231

Lui, P. P. Y., & Ng, S. W. (2013). Cell therapy for the treatment of tendinopathy—A systematic review on the pre-clinical and clinical evidence. *Seminars in Arthritis and Rheumatism*, 42(6), 651-666. doi: 10.1016/j.semarthrit.2012.10.004

Maher, C. G., Sherrington, C., Herbert, R. D., Moseley, A. M., & Elkins, M. (2003). Reliability of the PEDro scale for rating quality of randomised controlled trials. *Physical Therapy*, 83(8), 713-721.

Massei, M., Sanzo, P., & Przysucha, E. (2017). The Use of Therapeutic Taping in Individuals with Patellar Tendinopathy. *International Journal of Prevention and Treatment*, 6(1), 4-11.

Moseley, A. M., Herbert, R. D., Sherrington, C., & Maher, C. G. (2002). Evidence for physiotherapy practice: A survey of the Physiotherapy Evidence Database (PEDro). *The Australian Journal of Physiotherapy*, 48(1), 43-49.

Mostafavifar, M., Wertz, J., & Borchers, J. (2012). A systematic review of the effectiveness of kinesio taping for musculoskeletal injury. *The Physician and Sportsmedicine*, 40(4), 33-40. doi: 10.3810/psm.2012.11.1986

Nelson, N. L. (2016). Kinesio taping for chronic low back pain: A systematic review. *Journal of Bodywork and Movement Therapies*, 20(3), 672-681. doi: 10.1016/j.jbmt.2016.04.018

Parreira, P. do C. S., Costa, L. da C. M., Hespanhol, L. C., Lopes, A. D., & Costa, L. O. P. (2014). Current evidence does not support the use of Kinesio Taping in clinical practice: A systematic review. *Journal of Physiotherapy*, 60(1), 31-39. doi: 10.1016/j.jphys.2013.12.008

Rees, J. D., Wilson, A. M., & Wolman, R. L. (2006). Current concepts in the management of tendon disorders. *Rheumatology*, 45(5), 508-521. doi: 10.1093/rheumatology/kel046

Rees, Jonathan D, Stride, M., & Scott, A. (2014). Tendons – time to revisit inflammation. *British Journal of Sports Medicine*, 48(21), 1553-1557. doi: 10.1136/bjsports-2012-091957

Sanderson, L. M., & Bryant, A. (2015). Effectiveness and safety of prolotherapy injections for management of lower limb tendinopathy and fasciopathy: A systematic review. *Journal of Foot and Ankle Research*, 8, 57. doi: 10.1186/s13047-015-0114-5

Seo, H.-D., Kim, M.-Y., Choi, J.-E., Lim, G.-H., Jung, S.-I., Park, S.-H., Cheon, S.-H., & Lee, H.-Y. (2016). Effects of Kinesio taping on joint position sense of the ankle. *Journal of Physical Therapy Science*, 28(4), 1158-1160. doi: 10.1589/jpts.28.1158

Shakeri, H., Keshavarz, R., Arab, A. M., & Ebrahimi, I. (2013). Therapeutic Effect of Kinesio-taping on Disability of Arm, Shoulder, and Hand in Patients with Subacromial Impingement Syndrome: A Randomised Clinical Trial. *Journal of Novel Physiotherapies*, 3(4), 169.

Shakeri, Hassan, Keshavarz, R., Arab, A. M., & Ebrahimi, I. (2013). Clinical effectiveness of kinesiological taping on pain and pain-free shoulder range of motion in patients with shoulder impingement syndrome:

a randomised, double blinded, placebo-controlled trial. International *Journal of Sports Physical Therapy*, 8(6), 800-810.

Shih, Y.-F., Lee, Y.-F., & Chen, W.-Y. (2018). Effects of Kinesiology Taping on Scapular Reposition Accuracy, Kinematics, and Muscle Activity in Athletes With Shoulder Impingement Syndrome: A Randomized Controlled Study. *Journal of Sport Rehabilitation*, 27(6), 560-569. doi: 10.1123/jsr.2017-0043

Skjong, C. C., Meininger, A. K., & Ho, S. S. W. (2012). Tendinopathy treatment: Where is the evidence? Clinics in Sports Medicine, 31(2), 329-350. doi: 10.1016/j.csm.2011.11.003

Spencer, J. D., Hayes, K. C., & Alexander, I. J. (1984). Knee joint effusion and quadriceps reflex inhibition in man. *Archives of Physical Medicine and Rehabilitation*, 65(4), 171-177.

Taradaj, J., Halski, T., Zdunczyk, M., Rajfur, J., Pasternok, M., Chmielewska, D., Piecha, M., Kwaśna, K., & Skrzypulec-Plinta, V. (2014). Evaluation of the effectiveness of kinesio taping application in a patient with secondary lymphedema in breast cancer: A case report. *Przeglad Menopauzalny = Menopause Review*, 13(1), 73-77. doi: 10.5114/pm.2014.41082

Thelen, M. D., Dauber, J. A., & Stoneman, P. D. (2008). The clinical efficacy of kinesio tape for shoulder pain: A randomised, double-blinded, clinical trial. *The Journal of Orthopaedic and Sports Physical Therapy*, 38(7), 389-395. doi: 10.2519/jospt.2008.2791

Tsai, H.-J., Hung, H.-C., Yang, J.-L., Huang, C.-S., & Tsauo, J.-Y. (2009). Could Kinesio tape replace the bandage in decongestive lymphatic therapy for breast-cancer-related lymphedema? A pilot study. *Supportive Care in Cancer: Official Journal of the Multinational Association of Supportive Care in Cancer*, 17(11), 1353-1360. doi: 10.1007/s00520-009-0592-8

Unger, M., Carstens, J. P., Fernandes, N., Pretorius, R., Pronk, S., Robinson, A. C., & Scheepers, K. (2018). The efficacy of kinesiology taping for improving gross motor function in children with cerebral palsy: A systematic review. *The South African Journal of Physiotherapy*, 74(1), 459. doi: 10.4102/sajp.v74i1.459

Vercelli, S., Ferriero, G., Bravini, E., & Sartorio, F. (2013). How much is Kinesio taping a psychological crutch? *Manual Therapy*, 18(3), e11. doi: 10.1016/j.math.2012.10.008

Wang, Y., Gu, Y., Chen, J., Luo, W., He, W., Han, Z., & Tian, J. (2018). Kinesio taping is superior to other taping methods in ankle functional performance improvement: A systematic review and meta-analysis. *Clinical Rehabilitation*, 32(11), 1472-1481. doi: 10.1177/0269215518780443

Williams, S., Whatman, C., Hume, P. A., & Sheerin, K. (2012). Kinesio taping in treatment and prevention of sports injuries: A meta-analysis of the evidence for its effectiveness. *Sports Medicine*, 42(2), 153-164. doi: 10.2165/11594960-000000000-00000

Wilson, B., & Bialocerkowski, A. (2015). The Effects of Kinesiotape Applied to the Lateral Aspect of the Ankle: Relevance to Ankle Sprains--A Systematic Review. *PloS One*, 10(6), e0124214. doi: 10.1371/journal.pone.0124214

Wilson, F., Walshe, M., O'Dwyer, T., Bennett, K., Mockler, D., & Bleakley, C. (2018). Exercise, orthoses and splinting for treating Achilles tendinopathy: A systematic review with meta-analysis. *British Journal of Sports Medicine*, 52(24), 1564-1574. doi: 10.1136/bjsports-2017-098913

Wong, O. M. H., Cheung, R. T. H., & Li, R. C. T. (2012). Isokinetic knee function in healthy subjects with and without Kinesio taping. *Physical Therapy in Sport: Official Journal of the Association of Chartered Physiotherapists in Sports Medicine*, 13(4), 255-258. doi: 10.1016/j.ptsp.2012.01.004

Yeung, S. S., Yeung, E. W., Sakunkaruna, Y., Mingsoongnern, S., Hung, W. Y., Fan, Y. L., & Iao, H. C. (2015). Acute effects of kinesio taping on knee extensor peak torque and electromyographic activity after exhaustive isometric knee extension in healthy young adults. *Clinical Journal of Sport Medicine: Official Journal of the Canadian Academy of Sport Medicine*, 25(3), 284-290. doi: 10.1097/JSM.0000000000000132

Yoshida, A., & Kahanov, L. (2007). The effect of kinesio taping on lower trunk range of motions. *Research in Sports Medicine*, 15(2), 103-112. doi: 10.1080/15438620701405206

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Revised June 2019

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When preparing the final version of the manuscripts, either NEW or REVISED authors should strictly follow the guidelines. Manuscripts departing substantially from the guidelines will be returned to the authors for revision or, rejected.

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MJSSM honors a six-weeks for an initial decision of manuscript submission.

Authors should submit the manuscripts as one Microsoft Word (.doc) file.

Manuscripts must be provided either in standard UK or US English. English standard should be consistent throughout the manuscripts.

Format the manuscript in A4 paper size; margins are 1 inch or 2.5 cm all around.

Type the whole manuscript double-spaced, justified alignment.

Use Times New Roman font, size eleven (11) point.

Number (Arabic numerals) the pages consecutively (centering at the bottom of each page), beginning with the title page as page 1 and ending with the Figure legend page.

Include line numbers (continuous) for the convenience of the reviewers.

Apart from chapter headings and sub-headings avoid any kind of formatting in the main text of the manuscripts.

1.2. Type & Length

MJSSM publishes following types of papers:

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☑Open Submissions ☑Indexed ☑Peer Reviewed

Original scientific papers should be:
- Up to 3000 words (excluding title, abstract, tables/figures, figure legends, Acknowledgements, Conflict of Interest, and References);
- A structured abstract of less than 250 words;
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Original Scientific Paper

Transfer of learning on a spatial memory task

Selcuk Akpinar[1], Stevo Popović[1,2], Sadettin Kirazci[1]

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Word count: 2,980

Abstract word count: 236

Number of Tables: 3

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Nepocatych, S., Balilionis, G., & O'Neal, E. K. (2017). Analysis of dietary intake and body composition of female athletes over a competitive season. *Montenegrin Journal of Sports Science and Medicine, 6*(2), 57-65. doi: 10.26773/mjssm.2017.09.008

Duffield, R., & Marino, F. E. (2007). Effects of pre-cooling procedures on intermittent-sprint exercise performance in warm conditions. *European Journal of Applied Physiology, 100*(6), 727-735. doi: 10.1007/s00421-007-0468-x

Krustrup, P., Mohr, M., Amstrup, T., Rysgaard, T., Johansen, J., Steensberg, A., . . . Bangsbo, J. (2003). The yo-yo intermittent recovery test: physiological response, reliability, and validity. *Medicine and Science in Sports and Exercise, 35*(4), 697-705. doi: 10.1249/01.MSS.0000058441.94520.32

Journal article (online; electronic version of print source):

Williams, R. (2016). Krishna's Neglected Responsibilities: Religious devotion and social critique in eighteenth-century North India [Electronic version]. *Modern Asian Studies, 50*(5), 1403-1440. doi:10.1017/S0026749X14000444

Journal article (online; electronic only):

Chantavanich, S. (2003, October). Recent research on human trafficking. *Kyoto Review of Southeast Asia, 4*. Retrieved November 15, 2005, from http://kyotoreview.cseas.kyoto-u.ac.jp/issue/issue3/index.html

Conference paper:

Pasadilla, G. O., & Milo, M. (2005, June 27). *Effect of liberalization on banking competition*. Paper presented at the conference on Policies to Strengthen Productivity in the Philippines, Manila, Philippines. Retrieved August 23, 2006, from http://siteresources.worldbank.org/INTPHILIPPINES/Resources/Pasadilla.pdf

Encyclopedia entry (print, with author):

Pittau, J. (1983). Meiji constitution. In *Kodansha encyclopedia of Japan* (Vol. 2, pp. 1-3). Tokyo: Kodansha.

Encyclopedia entry (online, no author):

Ethnology. (2005, July). In *The Columbia encyclopedia* (6th ed.). New York: Columbia University Press. Retrieved November 21, 2005, from http://www.bartleby.com/65/et/ethnolog.html

Thesis and dissertation:

Pyun, D. Y. (2006). *The proposed model of attitude toward advertising through sport.* Unpublished Doctoral Dissertation. Tallahassee, FL: The Florida State University.

Book:

Borg, G. (1998). *Borg's perceived exertion and pain scales*: Human kinetics.

Chapter of a book:

Kellmann, M. (2012). Chapter 31-Overtraining and recovery: Chapter taken from Routledge Handbook of Applied Sport Psychology ISBN: 978-0-203-85104-3 *Routledge Online Studies on the Olympic and Paralympic Games* (Vol. 1, pp. 292-302).

Reference to an internet source:

Agency. (2007). Water for Health: Hydration Best Practice Toolkit for Hospitals and Healthcare. Retrieved 10/29, 2013, from www.rcn.org.uk/newsevents/hydration

2.5. Tables

All tables should be included in the main manuscript file, each on a separate page right after the Reference section.

Tables should be presented as standard MS Word tables.

Number (Arabic) tables consecutively in the order of their first citation in the text.

Tables and table headings should be completely intelligible without reference to the text. Give each column a short or abbreviated heading. Authors should place explanatory matter in footnotes, not in the heading. All abbreviations appearing in a table and not considered standard must be explained in a footnote of that table. Avoid any shading or coloring in your tables and be sure that each table is cited in the text.

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2.5.1. Table heading

Table heading should be written above the table, in Title Case, and without a full stop at the end of the heading. Do not use suffix letters (e.g., Table 1a, 1b, 1c); instead, combine the related tables. *See* example:

- ✓ **Table 1.** Repeated Sprint Time Following Ingestion of Carbohydrate-Electrolyte Beverage

2.5.2. Table sub-heading

All text appearing in tables should be written beginning only with first letter of the first word in all capitals, i.e., all words for variable names, column headings etc. in tables should start with the first letter in all capitals. Avoid any formatting (e.g., bold, italic, underline) in tables.

2.5.3. Table footnotes

Table footnotes should be written below the table.

General notes explain, qualify or provide information about the table as a whole. Put explanations of abbreviations, symbols, etc. here. General notes are designated by the word *Note* (italicized) followed by a period.

- ✓ *Note.* CI: confidence interval; Con: control group; CE: carbohydrate-electrolyte group.

Specific notes explain, qualify or provide information about a particular column, row, or individual entry. To indicate specific notes, use superscript lowercase letters (e.g. [a, b, c]), and order the superscripts from left to right, top to bottom. Each table's first footnote must be the superscript [a].

- ✓ [a]One participant was diagnosed with heat illness and n = 19.[b]n =20.

Probability notes provide the reader with the results of the texts for statistical significance. Probability notes must be indicated with consecutive use of the following symbols: * † ‡ § ¶ || etc.

- ✓ *P<0.05,†p<0.01.

2.5.4. Table citation

In the text, tables should be cited as full words. *See* example:

- ✓ Table 1 (first letter in all capitals and no full stop)
- ✓ ...as shown in Tables 1 and 3. (citing more tables at once)
- ✓ ...result has shown (Tables 1-3) that... (citing more tables at once)
- ✓ ....in our results (Tables 1, 2 and 5)... (citing more tables at once)

2.6. Figures

On the last separate page of the main manuscript file, authors should place the legends of all the figures submitted separately.

All graphic materials should be of sufficient quality for print with a minimum resolution of 600 dpi. MJSSM prefers TIFF, EPS and PNG formats.

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Figures and figure legends should be completely intelligible without reference to the text.

The price of printing in color is 50 EUR per page as printed in an issue of MJSSM.

2.6.1. Figure legends

Figures should not contain footnotes. All information, including explanations of abbreviations must be present in figure legends. Figure legends should be written bellow the figure, in sentence case. *See* example:
- ✓ **Figure 1.** Changes in accuracy of instep football kick measured before and after fatigued. SR – resting state, SF – state of fatigue, *p>0.01, †p>0.05.

2.6.2. Figure citation

All graphic materials should be referred to as Figures in the text. Figures are cited in the text as full words. *See* example:
- ✓ Figure 1
- × figure 1
- × Figure 1.
- ✓ ….exhibit greater variance than the year before (Figure 2). Therefore…
- ✓ ….as shown in Figures 1 and 3. (citing more figures at once)
- ✓ ….result has shown (Figures 1-3) that... (citing more figures at once)
- ✓ ….in our results (Figures 1, 2 and 5)... (citing more figures at once)

2.6.3. Sub-figures

If there is a figure divided in several sub-figures, each sub-figure should be marked with a small letter, starting with a, b, c etc. The letter should be marked for each subfigure in a logical and consistent way. *See* example:
- ✓ Figure 1a
- ✓ …in Figures 1a and b we can…
- ✓ …data represent (Figures 1a-d)…

2.7. Scientific Terminology

All units of measures should conform to the International System of Units (SI).

Measurements of length, height, weight, and volume should be reported in metric units (meter, kilogram, or liter) or their decimal multiples.

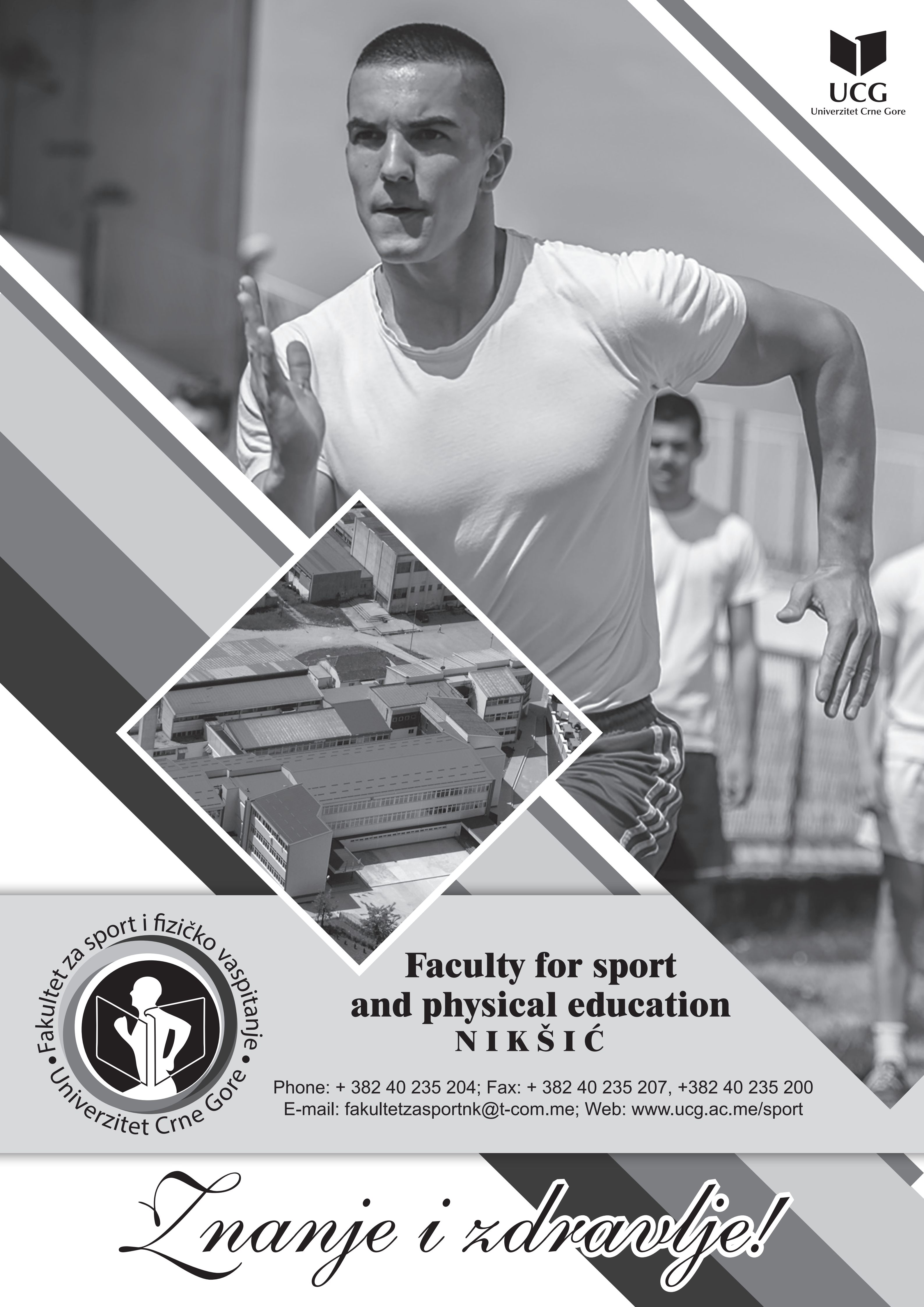
Decimal places in English language are separated with a full stop and not with a comma. Thousands are separated with a comma.

Percentage	Degrees	All other units of measure	Ratios	Decimal numbers
✓ 10%	✓ 10º	✓ 10 kg	✓ 12:2	✓ 0.056
× 10 %	× 10 º	× 10kg	× 12 : 2	× .056

Signs should be placed immediately preceding the relevant number.		
✓ 45±3.4	✓ p<0.01	✓ males >30 years of age
× 45 ± 3.4	× p < 0.01	× males > 30 years of age

2.8. Latin Names

Latin names of species, families etc. should be written in italics (even in titles). If you mention Latin names in your abstract they should be written in non-italic since the rest of the text in abstract is in italic. The first time the name of a species appears in the text both genus and species must be present; later on in the text it is possible to use genus abbreviations. *See* example:
- ✓ First time appearing: *musculus biceps brachii*
- ✓ Abbreviated: *m. biceps brachii*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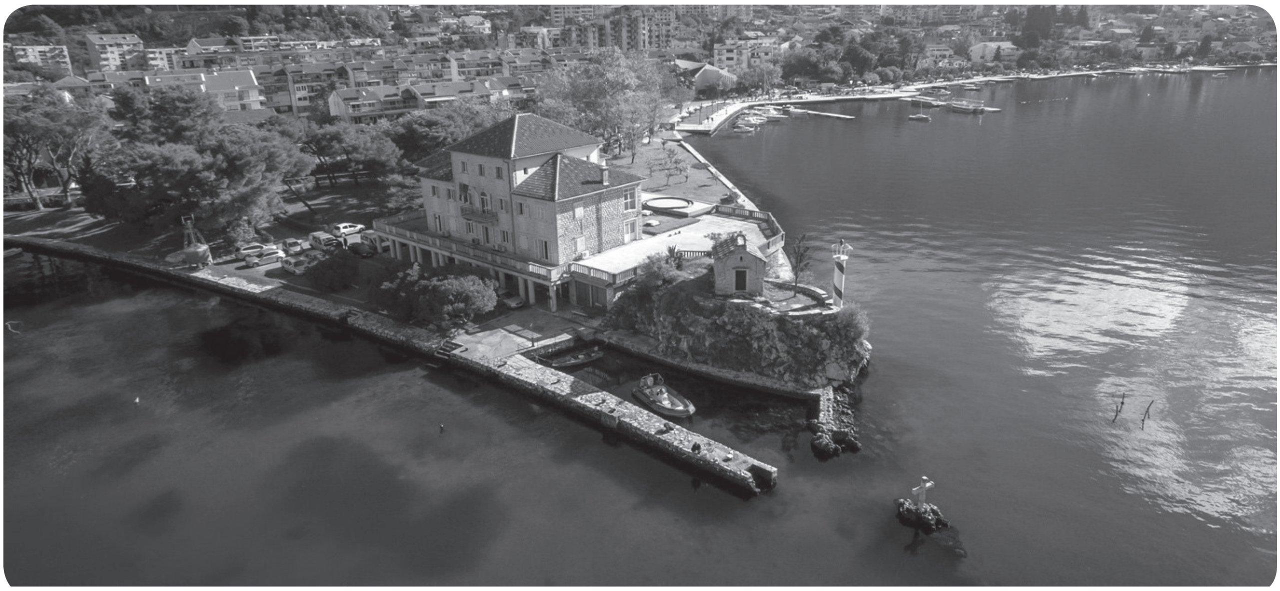

University of Montenegro – Institute for marine biology is located in Kotor, Montenegro. Since its establishment in 1961, the Institute performed comprehensive research of the marine and coastal area, which has its wide impact to the environmental protection, pollution-prevention and practical application. Core competencies of the Institute are focused on research in the fields of marine conservation, ichthyology and marine fisheries, marine chemistry, aquaculture, plankton research, neuro and eco-physiology. The main research area is investigating and protection of Adriatic sea with special interest of South Adriatic area. Institute for marine biology have a wide range of international cooperation with Marine research institutions and Universities all over Mediterranean area trough a numerous Eu funded scientific projects.

All over the year Institute is looking to hire a young students from the field of general biology, marine biology, marine chemistry, molecular biology or similar disciplines on voluntary basis to work with us. We need opportunity for international internship or MSc or PhD thesis that could be performed on Institute in our 5 different labs: Fisheries and ichthyology, Aquaculture, Marine chemistry, Plankton and sea water quality and Benthos and marine conservation.

Every year Institute organize several summer schools and workshop for interested students, MSc and PhD candidates. From 01-05 July 2019 we will organize Summer school “Blue Growth: emerging technologies, trends and opportunities” in frame of InnoBlueGrowth Project who is financed by Interreg Med programme. Through the specific theme courses, workshops and working labs offered – covering different areas of the blue economy – the Summer School aims at encouraging young people involvement in blue economy sectors by offering high-quality technical knowledge and fostering their entrepreneurial spirit. The Summer School will facilitate fruitful exchanges and a stronger understanding among a variety of actors coming from different Mediterranean countries with diverse profiles, including representatives from the academia, the public and private sectors, but also potential funders and investors. These activities will count on specific team building activities for participants as well to reinforce interpersonal skills and foster cohesion among blue academia and sectors.

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Since its foundation, the University of Montenegro has continuously been conducting reforms in the area of education and research, while since 2003 in line with the trends in EHEA. After adoption of the Bologna Declaration, University of Montenegro organized systematic preparation of documents aligned with it. Already in 2003, the experimental teaching programme started and today, all studies are organised in line with the Bologna principles. During the last two years systematic reforms of the University`s study programes have been conducted in order to harmonize domestic higher education system with European standards and market needs to highest extent.

The University of Montenegro has unique academic, business and development objectives. It comprises 19 faculties and two research institutes. The seat of the UoM is in Podgorica, the capital city, while university units are located in eight Montenegrin towns. The University support services and centers (advisory services, accounting department, international cooperation, career orientation) are located in the Rectorate.

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In 2015/16 there were a total of 1.192 employees at UoM, 845 of which were engaged in teaching. In the same year there were 20.236 students registered at all three cycles of studies.

Internationalization is high on the agenda of UoM priorities, thus it has participated in a number of international projects – over 50 projects funded under the Tempus programme, over 15 Erasmus Mundus Action 2 projects for student mobility, a number of projects under FP7 funding scheme or IPA supported projects, Erasmus + capacity building and International credit mobility projects and other.

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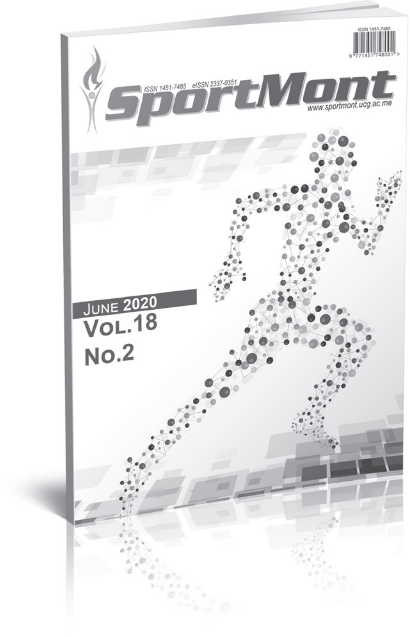

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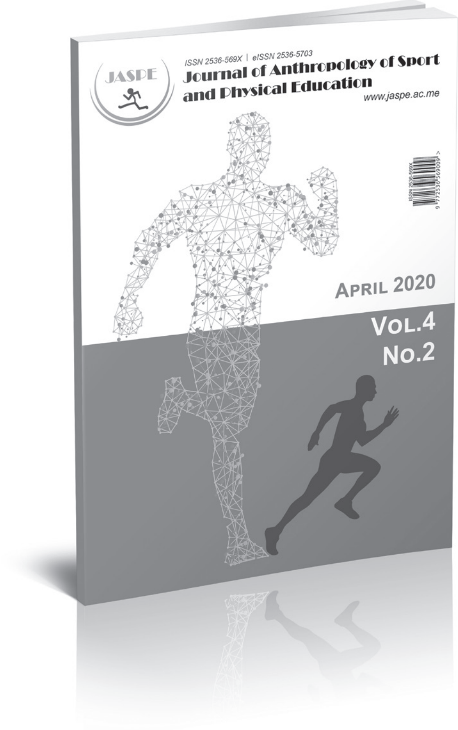

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