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ANTHROPOMETRIC AND PHYSICAL PERFORMANCE CHARACTERISTICS IN AFRICAN WOMEN FOOTBALL PLAYERS: A CROSS-SECTIONAL PILOT STUDY

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Abstract Being injured is inherent to participating in football activities; therefore, prevention of injuries is crucial. This requires that the risk factors for injury be established. However, such studies are rarely conducted in women athletes in Africa. The study's aim was to explore intrinsic risk factors for injury among African women football players using functional and musculoskeletal assessments. Participants (n = 40) completed demographic questionnaires; upper and lower limb active range of motion (AROM); muscle endurance and functional movement screening (FMS™) assessed. Median age [Q1; Q3] was 24 [20; 27] years. Participants performed 20.5 [0; 30.5] push-ups and 28 squats [30; 38] in 60s; and held the prone elbow plank for 46.2s [30.6; 64.5]. Median FMS™ score was 12 [10; 13]; most players (n = 27, 68%) could not execute a proper deep squat. Most players (70%; n = 28), were able to properly perform the in line lunge but scored poorly in the shoulder mobility domain of the FMS™, with 73% (n = 29) scoring ≤1. Players with a history of injury had lower FMS™ total (p = 0.02). Overall, participants presented with low muscle endurance and movement imbalances, which might predispose them to injury. Hence, strength and conditioning measures should be instituted in this population to prevent injuries.

Key words injury risk, muscle endurance, limb ROM, FMS, women's football, Africa

Introduction

Football is the most popular team sport worldwide (Williams, Coopoo, Fortuin, Green, 2019) and participation levels continue to increase (FIFA, 2014). However, participation in football carries an inherent risk of injuries (Junge, Dvořák, 2015). Therefore, prevention of injuries is crucial. In order to design effective preventative interventions, the aetiology and mechanisms of injuries should first be established (Van Mechelen, 1997). This includes assessment of the risk factors that are associated with these injuries. These are classified as intrinsic (inherent to the athlete e.g. age, muscle strength, flexibility) or extrinsic (external to the athlete e.g. training load, training surface) (Dvorak et al., 2000). To date, studies have identified risk factors for injuries in team sports such as rugby and football (Svensson, Alricsson, Olausson, Werner, 2018) and relevant preventative measures such as the FIFA 11+ program in football (Al Attar, Alshehri, 2019) and BokSmart in rugby (Sewry, Verhagen, Lambert, Van Mechelen, Brown, 2017) have been developed as a result.

Despite football being the most popular team sport among women and girls worldwide and participation increasing yearly (FIFA, 2014), relatively few of the studies on risk factors for injury have been conducted on women athletes in general or women football players specifically (Cruz, Oliveira, Silva, 2020). Hence, preventive measures developed are often derived from male cohorts. Furthermore, studies identifying risk factors for injuries among African women footballers are even scarcer as African women football players are currently on the periphery of global football medicine discourse (Mkumbuzi, Chibhabha, Zondi, 2021). When sustained, injuries in football players in low- and middle-income settings such as sub-Saharan Africa have different implications to those faced by their counterparts in high income settings as medical care is very limited in the former (Killowe, Mkandawire, 2005); therefore, primary, and secondary prevention of injuries is imperative in the former. However, the current paucity of empirical evidence that relates to women footballers in general and African women footballers specifically impairs the ability of team support personnel to prescribe preventative and treatment interventions that are relevant to this population. By understanding the particular risk factors that are unique to African women football players, interventions can be targeted towards their specific biopsychosocial circumstances (von Rosen, Frohm, Kottorp, Fridén, Heijne, 2017). This will improve assessment of injury risk, optimise prescription of prevention and treatment strategies as well as derive conclusive and appropriate recommendations for safe participation in football for African women football players. Therefore, the aim of this study was to investigate the intrinsic injury risk profiles of African women football players using functional and musculoskeletal screening assessments to provide an evidence base on which to develop or improve available injury prevention or interventions strategies in this population and promote safer participation in football.

Material and methods

Ethical clearance to conduct the study was obtained from the Faculty of Medicine Research Ethics Committee, Midlands State University, Zimbabwe (MSUFMEC 0002/10/20) and permission was obtained from the world football governing body and the tournament organisers. Participation in the study was voluntary, and it was conducted according to the principles of the Helsinki Declaration. In addition to permission, verbal and written informed consent to participate in the study were obtained from the participants.

This study assessed injury risk parameters in African women football players participating in the 2020 Council of Southern African Football Associations (COSAFA) Women's Championship held in Gqeberha (formerly Port Elizabeth), South Africa.

All senior (≥18 years old) football players participating in the tournament (n = 177) were eligible to participate in the study. Players who had any injuries at the time of testing were excluded. The players were requested to present for testing at a time and day that was convenient for them during the tournament. This pragmatic approach for recruitment and testing was adopted to minimise disrupting their training, competitive, and recovery schedules. At the visit, (1) demographic and anthropometric measures, (2) musculoskeletal assessments, (3) functional movement screening (FMS™), and (4) muscular endurance were assessed. This array of tests has been used previously to assess injury risk in team sports (Mtsweni, West, Taliep, 2017; Sewry et al., 2017).

Demographic data such as calendar age, skill level, training and injury history were recorded on a self-administered questionnaire and anthropometric data were measured including height (wall tape measure), mass (balance) and limb girths (tape measure). The girths of the upper limb (at deltoid insertion), abdomen (at the navel), hip (widest part of the hip), thigh (halfway between the hip and knee joints), and calf (widest part of the calf) were measured as proxies for muscle girth.

Following this, a sports physiotherapist (NSM) conducted musculoskeletal assessments: active knee extension, modified Thomas test, active internal and external rotation of the hip (seated position, hip and knee at approximately 90° flexion), ankle dorsiflexion (weight bearing lunge test), sit and reach, lumbar spine extension, lumbar spine forward flexion, and shoulder internal and external rotation, as reported in previous literature (Sewry et al., 2017). The Functional Movement Screen (FMS™) (Chalmers et al., 2017) was then administered. The FMS involves the participant performing the deep overhead squat, single leg hurdle step, in line lunge, active straight leg raise, trunk stability push up, seated rotary stability and shoulder mobility (Chalmers et al., 2017). The movement patterns are scored from 0 (pain with execution of movement) to 3 (perfectly executed movement) points, with the total score ranging from 0–21 points (Cook, Burton, Hoogenboom, 2006a, 2006b). Muscle endurance of the upper-limbs was measured using the modified push-up test. Participants started the test with their knees bent on the floor, their hands shoulder width apart on the floor, with a straight back (Mtsweni et al., 2017). The total number of modified push-ups performed in 30s and 60s was recorded. Muscle endurance of the mid-body/core was measured with the prone elbow plank to exhaustion (Abdallah, Mohamed, Hegazy, 2019). Muscle endurance of the lower body was measured using deep squats (Eckard et al., 2018). The total number of squats performed in 30s and 60s was recorded.

Statistical analyses

The data were analysed using STATA™ v 14 (StataCorp, Texas, USA). Data for each outcome variable were tested for normality using the Shapiro-Wilk's test. Continuous variables are presented as mean ± standard deviation [or median (Q1; Q3)] and categorical variables as n(%). If normally distributed, comparisons among the participants were performed using the t-test. Otherwise, then the Wilcoxon signed rank test or Kruskall-Wallis test were used. The Pearson's Chi square test was used to test for associations among categorical variables. Where significant differences were found, univariate models (logistic for categorical variables; linear for continuous variables) were performed to determine where the differences were located. Level of significance was set at $p \leq 0.05$.

Results

Of the 177 football players who participated in the 2020 COSAFA Women's tournament, 40 (22.5%) agreed to participate in the study. The median age [Q1; Q3] of the participants was 24 [20; 27] years (Table 1). Nearly

Table 1. Demographic and physical characteristics of African women football players participants at the 2020 COSAFA Women's tournament (n = 40)

Variable	Score
Age (years)	24 [20.3; 27]
Height (m)	1.60 [1.57; 1.65]
Mass (kg)	58 [55; 65]
BMI (kg.m^{-2})	22.3 [20.5; 24.6]
Dominant leg	
Left	5 (12.5)
Both	7 (17.5)
Right	28 (70)
Playing position	
Goalkeeper	2 (5)
Defender	11 (27.5)
Midfielder	13 (32.5)
Striker	14 (35)
Skill level	
Semi-professional	1 (2.5)
Professional	13 (32.5)
Amateur	21 (52.5)
Not specified	5 (12.5)
Football participation (years)	10 [7; 13]
Football competition (years)	7 [4; 10]
Football training last 0 to 3 months (hrs/week)	8.5 [6; 11.5]
Football training last 4 to 12 months (hrs/week)	10 [10; 12]
Football training last 13 to 24 months (hrs/week)	10 [10; 16]
History of injury	
Yes*	31 (77.5)
Head/face	1 (3.2)
Wrist/hand	1 (3.2)
Torso	2 (6.4)
Ankle	2 (6.4)
Shoulder	4 (12.9)
Foot/toe	5 (16.1)
Hip/thigh	7 (22.6)
Knee	9 (29.0)
No	7 (17.5)
Not specified	2 (5)
Limb girths (cm)	
Upper arm	25.8 [24; 26.8]
Abdomen	73.0 [69.5; 75.3]
Hip	96.5 [91.8; 101]
Thigh	51.8 [46.8; 55]
Calf	34.3 [32; 36]

* Some participants reported more than one injury; Dominant leg, playing position, skill level, and history of injury are expressed as n(%). The remaining variables are expressed as median [Q1; Q3].

half of the participants (n = 21; 52.5%) described themselves as amateur level players and had participated in football for 10 [7; 13] years and football competitions for 7 [4; 10] years. A history of injury was reported by 77.5% (n = 31) of players. No differences in baseline characteristics: age (p = 0.83); height (p = 0.72); weight (p = 0.40), BMI (p = 0.37), and amount of football training in the preceding 24 months were observed between amateur and professional players. Therefore, they were not separated for further analysis. Additionally, no differences in baseline characteristics were noted between players who were left or right side dominant and most of the players were right hand (87.5%, n = 35) and leg (70%, n = 28) dominant, the musculoskeletal assessment results on the right upper or lower limbs were taken for analysis.

Active joint range of motion (AROM), sit and reach, lumbar flexion and extension and Thomas test values are presented in Table 2. There were no significant differences between amateur and professional players for all musculoskeletal assessments; modified Thomas test (p = 0.75), weight bearing lunge test (p = 0.09), sit and reach scores (p = 0.16).

Table 2. Musculoskeletal assessments and muscle endurance scores for the upper and lower limbs among African women football players participants at the 2020 COSAFA Women's tournament (n = 40)

Test	Score median [Q1;Q3]
Active knee extension (°)	–3 [–4; –1]
Thomas test (°)	–3 [–2; –6]
Active shoulder Internal rotation (°)	75 [69; 81]
Active shoulder external rotation (°)	84 [80; 95]
Active hip internal rotation (°)	18 [13; 37]
Active hip external rotation (°)	15 [12; 20]
Weight bearing lunge (cm)	9 [8; 11]
Sit and reach (cm)	14.15 [10; 19.8]
Active lumbar flexion (cm)	9.5 [7.5; 11]
Active lumbar extension (cm)	5.8[3; 9]
Modified push-ups_30s (n)	18.5 [12; 23.5]
Modified push ups_60s (n)	20.5 [0; 30.5]
Squats_30s (n)	16 [14; 19.5]
Squats_60s (n)	28 [30; 38]
Prone elbow plank (s)	46.2 (30.6; 64.5]

The number of push-ups at 30s predicted the number of push-ups at 60s ($p < 0.001$) and players with an injury history performed fewer push-ups at 60s (p = 0.01). However, this was not significant when adjusted for age, mass, skill level, years of training in the sport, or hours of training in the preceding three (3) months. The number of squats a player could perform in 60s was not predicted by their hip (p = 0.75), thigh (p = 0.08) or calf (p = 0.17) circumference. Additionally, the player's abdominal circumference did not predict the amount of time spent in the prone plank (p = 0.28). Similarly, abdominal girth did not predict number of squats at 30s (p = 0.16) or 60s (p = 0.50). The number of squats at 60s was not influenced by hours of training per week in the preceding 3 to 24 months (p = 0.79), age (p = 0.86), height (p = 0.24), weight (p = 0.16), skill level (p = 0.57) or previous injury (p = 0.06). There was no relationship between the amount of time for the prone plank and history of injury (p = 0.08) even when adjusted for age, mass, height, skill level, years of experience in sport and hours of training in the preceding 3 months. No differences between amateur and professional players were noted in the muscle endurance scores for push-ups (p = 0.99), prone plank (p = 0.55) or squats (p = 0.57).

The median [Q1; Q3] FMS™ score was 12 [10; 13]. None of the players scored a perfect total; the minimum score obtained was 2 and the maximum score was 15. Most players (n = 27, 68%) could not execute a proper deep squat; only 32% (n = 13) performed a proper deep squat (Table 3). Similarly, 28% (n = 11) of athletes performed the hurdle step with proper form. Most players, 70% (n = 28), were able to perform the in line lunge properly. Further, 58% (n = 23) of the athletes were able to perform the straight leg raise and the stability push-up with proper form. Most players scored poorly in the shoulder mobility domain with 73% (n = 29) scoring ≤1. There were no differences between the total FMS™ scores of professional and amateur players (p = 0.91). FMS™ total score was influenced by a history of injury: those who had previous injury had lower FMS™ scores (p = 0.02). However, it was not influenced by age (p = 0.10), height (p = 0.07), mass (p = 0.06), skill level (p = 0.44) or hours of training in the previous 3 months (p = 0.77), 12 months (p = 0.93) or 24 months (p = 0.19).

Table 3. Individual FMS™ scores* for African women football players participants at the 2020 COSAFA Women's tournament (n = 40)

FMS™ domain	0 n(%)	1 n(%)	2 n(%)	3 n(%)
Deep squat	3 (7.5)	6 (15)	18 (45)	13 (33)
Hurdle step	3 (7.5)	1 (2.5)	25 (63)	11 (28)
In- line lunge	3 (7.5)	2 (5.0)	7 (18)	28 (70)
Straight Leg Raise	3 (7.5)	1 (2.5)	13 (33)	23 (58)
Shoulder mobility	3 (7.5)	26 (65)	7 (18)	4 (10)
Stability push up	3 (7.5)	1 (2.5)	13 (33)	23 (58)

The number of football players who scored each score for every domain are presented as absolute figures (n) and percentage (%) of total.
* The scores for the rotary stability test are not included because the investigators (inexplicably) omitted this test.

No associations were observed between shoulder internal and external AROM and FMS™ scores for stability push-up, shoulder mobilisation and the FMS™ total score (p > 0.05). The ankle dorsiflexion AROM was not associated with FMS™ scores in the squat (p = 0.93), or in line lunge (p = 0.15). However, ankle dorsiflexion AROM was associated with the FMS score in the hurdle step (p = 0.01). No associations were observed between hip internal (p = 0.77) and external rotation (p = 0.88) AROM and FMS™ scores in the squat, hurdle step, or in line lunge. Additionally, no associations were noted between sit and reach scores and straight leg raise (SLR) (p = 0.93); no associations were noted between active lumber flexion (p = 0.72), extension (p = 0.44) and SLR scores. Furthermore, FMS™ squat scores were independent of thigh (p = 0.547), calf (p = 0.91) or hip (p = 0.70) girth and FMS™ stability push scores were not influenced by upper arm girth (p = 0.70). However, players who scored high on the FMS™ squat also did more squats in 60s (p = 0.03).

Knee extension AROM was not associated with injury (p = 0.29) but not when adjusted for thigh girth (p = 0.04). Hip external rotation AROM was associated with history of previous injury (p = 0.01) but not after adjustment for age, height, mass, leg dominance and hip girth. Sit and reach values (p = 0.15) and ankle dorsiflexion AROM values (p = 0.66) were not associated with history of injury.

Discussion

The main findings of this study were that, in a cohort of African women football players, most players presented with a reduced range of motion in the shoulder, hip and ankle. Additionally, the players could perform on average 20.5 push-ups in 60 s and could hold the prone elbow plank for an average of 46.2 s. Furthermore, 67% of the players could not execute a proper deep squat, 72% could not execute a proper hurdle step, 70% performed the in-line lunge properly, and 73% scored ≤1 on the shoulder mobility domain. Additionally, lower FMS™ scores in certain domains were associated with lower muscle endurance in the corresponding muscle region. These findings suggest a high intrinsic risk of injury in this cohort.

Players in this cohort presented with lower AROM, in particular hip internal and external rotation, than reported in other football cohorts (Mentiplay et al., 2019; Mosler et al., 2017). A correlation between decreased joint ROM and increased risk of injury has been shown previously (Tak et al., 2016). Hip AROM is key in football performance as it determines kicking and inside passing, which are central actions of the game, and require considerable hip AROM. Additionally, the importance of hip AROM is further emphasised by its association with anterior cruciate ligament (ACL) injury risk and prevention programs (Bedi et al., 2016; Omi et al., 2018). However, this finding is equivocal (Tak et al., 2017a; Whittaker, Small, Maffey, Emery, 2015). These observed differences could be because of heterogeneity in measurement techniques used in different studies (Whittaker et al., 2015; Li et al., 2015; Tak et al., 2017b), which limits direct comparisons and ought to be considered in the interpretation of the results. In particular, measuring hip rotation ROM in the seated position has been shown to yield lower values than in prone lying (Simoneau, Hoenig, Lepley, Papanek, 1998) and may also explain the low values obtained in our cohort.

Upper limb, core and lower limb muscle endurances in this cohort were lower than previously reported in the literature (Abdallah et al., 2019; Mentiplay et al., 2019). However, our results are similar to results in cohorts of African women basketball players (Mtsweni et al., 2017) and South African women football players (Williams et al., 2019). Previously, core stability, neuromuscular core and core proprioception have been associated with injury risk, while the relationship between core endurance and injury is conflicting (De Blaiser et al., 2018). However, more recent work demonstrates a strong association between core endurance and (prospective) development and frequency of overuse and lower limb injuries (Abdallah et al., 2019; De Blaiser, De Ridder, Willems, Vanden Bossche, Danneels, Roosen, 2019). Low core muscle endurance may lead to non-contact injuries directly through inability to produce sufficient force to maintain trunk stability once the muscles fatigue, as would be observed in the second half or extra time of a football match (Zazulak, Cholewicki, Reeves, 2008). This limits the body's ability to control its centre of mass forcing the lower limbs to compensate, making one susceptible to injury (Abdallah et al., 2019). Additionally, core muscle fatigue also leads to altered landing biomechanics, which may contribute to altered lower limb movements during play and hence injury (Read, Oliver, De Ste Croix, Myer, Lloyd, 2018). Therefore, targeted muscle endurance training should be an integral part of injury prevention strategies in cohorts such as ours (McCall, Dupont, Ekstrand, 2016).

The observed low FMS™ scores suggest poor fundamental movement pattern quality. This is supported by our finding that players with higher FMS™ scores in certain domains had greater muscle endurance in the corresponding muscle region, which suggests that proper form leads to improved performance measures. Poor fundamental movement patterns suggest muscle weaknesses in some muscle groups which leads to compensatory movements and may lead to increased injury risk (Cook et al., 2006b, 2006a; Eckard et al., 2018). Indeed, low FMS™ scores have been associated with increased risk of injury in some studies (Šiupšinskas, Garbenytė-Apolinskienė, Salatkaitė, Gudas, Trumpickas, 2019) though others have not (Schroeder, Wellmann, Stein, Braumann, 2016). Furthermore, evidence is available to recommend against the FMS™ as a standalone tool for injury risk analysis in football (Newton et al., 2017). The FMS™ is, however, a relatively affordable tool, easy to administer, and score, which would make it accessible to most practitioners in low- and middle-income environments to assess injury risk when used in combination with other tools. Additionally, results of the FMS™ can still be useful to design strength and conditioning programs during preseason in those athletes with identified deficiencies (Newton et al., 2017).

Overall, players in this cohort presented with considerable intrinsic risks for injury. These are of concern on their own, but more so when experienced in combination with a multitude of extrinsic risk factors such as poor training environments (Chalmers et al., 2011). While broader structural and administrative constraints may explain the extrinsic risk factors for African women football teams, the risk factors observed herein are modifiable at a personal/team level, mainly through strength and conditioning programs (Brooks, Fuller, Kemp, Reddin, 2006). These strength and conditioning programs can be done at fairly low or no cost and even with minimal or no equipment. Therefore, there is a need to develop systematic models to screen African women football players and subsequently develop context relevant programs to reduce injury risk. However, there is a shortage of qualified personnel to work with women football teams (Geertsema et al., 2021). It is, however, noteworthy that existing coach led injury prevention programs such as FIFA 11+ have been demonstrated to reduce injury risk parameters (Sadigursky et al., 2017); therefore, their role in injury prevention should be re-emphasised especially in resource limited cohorts.

This study is not without limitations. Firstly, there is a risk of non-participation bias in our cohort; less than 25% of the players at the tournament agreed to participate. It is possible that those who participated in the study were the ones who had impairments in movement quality and would thus be drawn to such a study. Secondly, more sensitive tests could have been used to collect the data in this study. However, in resourced constrained settings, the methods used are easily accessible and repeatable for monitoring football players in this regard. Thirdly, while conducting the FMS™ testing, the rotary stability test was omitted. Hence, we have an incomplete view of composite FMS™ scores. However, we did conduct the prone elbow bridge to assess core endurance; hence we can, to some extent, extrapolate on the stability of core musculature from these values. Further, the measurements taken in this study could have been repeated thrice to ascertain intra-tester reliability. However, as this study was conducted during a tournament, we had limited time with the participants in between their training, match, and recovery schedules. Lastly, this is a cross sectional study of a small sample of participants; therefore, these results should be generalised to African women football players with caution.

In conclusion, African women football players in this cohort presented with reduced joint range of motion, low muscle endurance, and low FMS™ scores, which suggests high intrinsic risk of injury. Therefore, there is a need to develop systematic models to screen African women football players and subsequently develop context relevant programs to reduce injury risk. In particular, proper strength and conditioning programs should be instituted in this population to improve muscle endurance, movement quality and, ultimately, reduce injury risk. However, as there is a shortage of qualified personnel to work with women football teams, the role of existing coach led injury prevention programs in injury prevention should be re-emphasised.

Perspectives

Numerous studies on intrinsic risk factors in sport have been conducted in female athletes. However, few of these are in women athletes from low- and middle-income settings. This limits the development of context relevant, holistic injury prevention protocols that account for their particular biopsychosocial circumstances. This study showed that this cohort of African women football players present with considerable (modifiable) intrinsic risk factors for injury. Biology does not exist in a vacuum; therefore, any corrective or preventative strategies such as strength and conditioning programs ought to be considered within these players' context of concomitant extrinsic risk factors for injury such as (lack of) proper equipment, infrastructure, qualified personnel, as well as prevailing negative socio-cultural norms towards strength training in female athletes.

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Data availability statement

Individual, de-identified data collected in the study will be made available following publication, for aims approved in the proposal and upon reasonable request to the corresponding author on nonhlanhla@ntombisport.com. These data will be available for 3 years after publication.

Patient consent for publication

Not required.

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LOWER EXTREMITIES JOINT ANGLES DURING SQUATS – UNDEREXPLORED PARAMETER OF STANDARD REHABILITATION AND SPORTS EXERCISE

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Abstract The purpose was to specify the lower extremity joint angles in different squats for the future development of adequate computational models of the joints.
Methods. We investigated joint angles in the lower extremity joints in 103 athletes in different types of squats with and without added weight (barbell) 75% of 1 repetition maximum.
Results. The mean knee and hip flexion and ankle dorsiflexion angles in horizontal squats are respectively 113.42°, 128.21°, and 23.27°; in half-squats 70.60°, 87.94°, and 15.60°; in lunges 98.04°, 96.36°, and 8.02°; in Smith machine squats 94.42°, 106.28°,

and 4.46°. In a horizontal squat with a barbell, the knee joint flexion and the ankle joint dorsiflexion angles are significantly larger (by 4.56° and 3.11°, respectively) than in squats without added weight. The knee joint flexion and ankle dorsiflexion angles in lunges are significantly less in barbell squats (by 4.15° and 4.37°, respectively). The knee flexion angle in horizontal barbell squats in male athletes is significantly larger than in female athletes (by 4.71°).
Conclusions. The mean knee and hip flexion and ankle dorsiflexion angles in different types of squats are established and may be used for further research. Horizontal squats produce greater lower extremity joint angles.

Key words squats, joint angles, half-squats, Smith machine squats, lunges

Introduction

Squats are an essential exercise in the training process in many sports and a competitive exercise in powerlifting. Horizontal squats are the standard of its performance (during the competition, you need to sit at least a little below the horizontal level) (United States Powerlifting Association, 2016). Despite this, there are almost no studies of the average angles in athletes' knee, ankle, and hip joints during this exercise. There are specific standards and guidelines for squat technique (United States Powerlifting Association, 2016). However, depending on the sport, experience, the aim of performing squats, and anthropometric measures of athletes, even the same type of squat can be performed in different ways by different athletes (Lorenzetti et al., 2018; Myer et al., 2014), and the angles in the knee, hip, and ankle joints will differ significantly. Athletes who are well acquainted with the correct squat technique and have mastered it before injury or surgery, of course, will be better able to follow the instructions of a rehabilitation therapist, physical therapist, or kinesiotherapy specialist. So we must choose their technique, and hence the joint angles, as a standard. However, even among athletes, the technique of squats differs significantly while remaining within the recommended limits.

Studies that we have found either do not indicate squat depth and methods of calculating joint angles (85–106° (Lorenzetti et al., 2012)) or study deep squat (full squat) with maximum flexion in the knee joints (104.8–121.5° (McKean, Burkett, 2012), 119.0–124.8° (Zawadka, Smolka, Skublewska-Paszkowska, Lukasik, Gawda, 2020), 124.3–125.2° (Endo, Miura, Sakamoto, 2020)) which may be dangerous even for healthy athletes and even more so for patients with injuries and diseases of the joints (Escamilla, 2001; Li, Adrien, Baker, Mei, Gu, 2021). Besides this, among the described studies one investigated only 9 (Endo et al., 2020), the other 60 volunteers (Zawadka et al., 2020), but all of them were neither professional athletes nor specially trained in squatting. A critical study by Fry et al. was performed on only seven volunteers and studied only horizontal squats with the weight bar (Fry, Smith, Schilling, 2003). The most informative in this regard was the study of powerlifters and weightlifters conducted by Wretenberg, Feng, Arborelius back in 1996. Scientists have determined that the average knee joint angle during squatting to the horizontal (most likely using the neutral-zero method) in powerlifters was 111° ±5° and in weightlifters 116° ±5°. In a deep squat, these angles were 126° ±4° and 138° ±3°, respectively (Wretenberg et al., 1996). However, the study was performed on only 14 athletes and did not evaluate the forward tilt angle of the tibia, which is essential for the proper development of a computational model (especially one that takes into account the angle of the tibia plateau slope) and for tensile load test with a direct stress machine in different squats.

Squats in various modifications are widely used during rehabilitation and physical therapy for numerous injuries and diseases of the joints and after joint surgery. The matters of current interest are the following. How and what squat techniques affect specific anatomical structures of the joints? What squat modifications, at what time after injury or surgery, and with what load can we safely utilize? These issues are especially relevant for the rehabilitation of patients after reconstructive joint surgery, such as anterior cruciate ligament reconstruction. We must have a clear idea of what loads await the patient during squats. In this regard, we must understand, among other factors, the lower extremities joint angles during squats for further load calculations. Today, computer-generated simulations of joint stresses in various exercises and tensile load tests with a direct stress machine are beneficial in choosing the safest exercises and modifying their techniques to maximize the safety of their use in the rehabilitation of injuries and diseases of the joints. We need to know the average joint angles in each type of squat and the range of their oscillations between athletes/patients, as well as the angle of the tibia forward tilt to develop an adequate computational model of the knee joint for stress analysis in the anatomical elements of the knee joint (including the anterior cruciate ligament) using the finite element method and for tensile load test with a direct stress machine. We encountered the absence of these data in the scientific literature. This prompted us to conduct independent research.

The purpose of the study was to specify the lower extremity joint angles in different types of squats and the range of their oscillations for further development of an adequate computational model of the joint for stress analysis in its anatomical elements using the finite element method and for tensile load test with a direct stress machine.

Material and methods

We investigated joint angles in the knees, ankles (anterior tibial deviation angle between the floor and the shin axis), and hip joints in horizontal squats, half-squats, Smith machine squats, and lunges in 103 athletes (47 male and 56 female) engaged in weightlifting, powerlifting, bodybuilding or CrossFit with athletic titles and categories in strength sports or experience of regular strength training and squats at least 3 three times a week for at least ten years. Athletes were studied in different gyms to eliminate the subjectivity of one coach's recommendations.

There is some controversy in terminology regarding quarter squats, semi-squats, half-squats, full, parallel, and deep squats. Semi-squats are sometimes called quarter squats, and Escamilla calls semi-squat the squat to the horizontal (Escamilla, 2001). We will adhere to the more traditional terminology, where horizontal squats are the squats to the horizontal position of the thighs, and semi-squats (or half-squats) are the squats where the thighs are angled at 45 degrees to the horizontal.

After the warm-up, athletes who are well-versed in the squat technique were given the instructions to perform a horizontal squat, half-squat, Smith machine squat, and lunge with the best technique. The hip, knee, and ankle angles were measured with the neutral-zero method. The ankle angle (dorsal flexion) was measured as the tibial shaft forward tilt angle. The athlete was allowed to utilize the squatting technique he would use to fulfill the medical prescriptions regarding rehabilitation. Most athletes used mirrors in the gym for squat performance self-control. On the other hand, some of the athletes squatted without a mirror as they had used to such a technique. All the athletes were free of injuries and joint diseases that could interfere with the proper squatting technique. The added weight of 75% of 1 repetition maximum was used only by the athletes who knew their one-repetition maximum with the ideal squatting technique and were familiar with such a weight at workouts. Not all the professional athletes that utilize squats at their training sessions perform these with the maximal weight and know their one-repetition maximum.

Horizontal squats were studied in 103 athletes (47 male and 56 female), Smith machine squats were studied in 57 athletes (31 male and 26 female), half-squats – in 48 (20 male and 28 female), lunges – in 45 (20 male and

25 female). Fewer athletes were investigated performing half-squats, Smith machine squats, and lunges due to later decisions about including these exercises in the research and due to fewer athletes who routinely use these exercises in the training process and feel up to perform these exercises at a high level with ideal technique. We also studied the above-mentioned angles in the joints of the lower extremities, both among all surveyed athletes and separately for men and women and separately for squats without the extra weight and with added weight (barbell) 75% of 1 repetition maximum. Smith machine squats were performed with a 20 kg weight bar, which was an integral part of the machine. Because only a small number of athletes knew their one-repetition maximum in the Smith machine, barbell squats in the Smith machine were not studied separately.

Squats were performed with the feet approximately shoulder-width apart. In the case of squats with added weight (barbell), its weight bar was placed high on the back – on the trapezius muscle.

Results

We determined that the knee (flexion), hip (flexion), and ankle (dorsiflexion) angles in athletes of strength sports in horizontal squats are respectively 113.42° ±7.20°, 128.21° ±9.35°, and 23.27° ±6.23°; in half-squats 70.60° ±17.44°, 87.94° ±17.80° and 15.60° ±6.61°; in lunges 98.04° ±5.82°, 96.36° ±7.28° and 8.02° ±5.94°; in Smith machine squats 94.42° ±4.78°, 106.28° ±9.14° and 4.46° ±4.80°. The specified mean angles (and their standard deviations), ranges of the hip, knee, and ankle angles in different squats, separately for squats with and without added weight (barbell), for male and female athletes, are listed in Table 1 and schematically shown in Figure 1. Table 2 presents the difference and the significance of the difference in these angles in different squats between male and female athletes, between squats with and without added weight.

Table 1. The mean hip, knee, and ankle angles in different squats, their standard deviations, and ranges

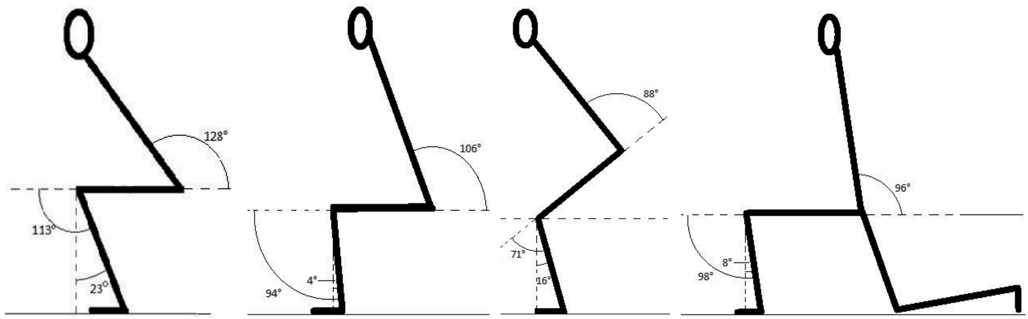
The subgroup of athletes and their number	The knee joint flexion angle	The hip joint flexion angle	The ankle joint dorsiflexion or extension angle (same as tibial shaft forward tilt angle)
1	2	3	4
Horizontal squats			
All athletes 103	113,42° ±7,20° (95–132°)	128,21° ±9,35° (105–150°)	23,27° ±6,23° (11–37°)
Male athletes 47	114,64° ±6,07° (100–127°)	129,96° ±9,03° (109–150°)	24,49° ±6,12° (11–35°)
Female athletes 56	112,39° ±7,94° (95–132°)	126,75° ±9,44° (105–147°)	22,25° ±6,20° (11–37°)
All athletes without a barbell 52	111,19° ±7,47° (95–127°)	128,37° ±8,95° (110–148°)	21,73° ±6,10° (11–37°)
Male athletes without a barbell 22	113,91° ±6,45° (100–127°)	129,59° ±9,43° (110–148°)	23,23° ±5,98° (11–34°)
Female athletes without a barbell 30	109,20° ±7,64° (95–127°)	127,47° ±8,62° (115–147°)	20,63° ±6,06° (11–37°)
All athletes with a barbell 51	115,69° ±6,20° (103–132°)	128,06° ±9,83° (105–150°)	24,84° ±6,02° (11–35)
Male athletes with a barbell 25	115,28° ±5,77° (105–126°)	130,28° ±8,84° (109–150°)	25,60° ±6,15° (15–35°)
Female athletes with a barbell 26	116,08° ±6,67° (103–132°)	125,92° ±10,42° (105–145°)	24,12° ±5,93° (11–30°)

1	2	3	4
		Half-squats	
All athletes 48	70,60° ±17,44° (47–114°)	87,94° ±17,80° (40–120°)	15,60° ±6,61° (3–26°)
Male athletes 20	67,30° ±14,92° (47–111°)	91,20° ±17,12° (40–120°)	13,70° ±6,33° (3–24°)
Female athletes 28	72,96° ±18,94° (47–114°)	85,61° ±18,22° (57–120°)	16,96° ±6,57° (7–26°)
All athletes without a barbell 38	63,17° ± 13,16° (47–80°)	90,92° ±18,79° (40–117°)	10,00° ±4,59° (3–16°)
All athletes with a barbell 10	73,50° ±16,11° (60–111°)	91,63° ±15,50° (71–120°)	19,25° ±4,13° (13–24°)
		Lunges	
All athletes 45	98,04° ±5,82° (90–110°)	96,36° ±7,28° (90–116°)	8,02° ±5,94° (0–21°)
Male athletes 20	99,05° ±5,25° (90–108°)	97,35° ±6,77° (90–116°)	8,9° ±5,18° (0–18°)
Female athletes 25	97,24° ±6,22° (90–110°)	95,56° ±7,71° (90–113°)	7,32° ±6,50° (0–21°)
All athletes without a barbell 34	99,06° ±5,82° (90–110°)	95,41° ±6,60° (90–113°)	9,09° ±6,00° (0–21°)
All athletes with a barbell 11	94,91° ±4,78° (90–102°)	99,27° ±8,80° (90–116°)	4,72° ±4,52° (0–10°)
		Smith machine squats	
All athletes 57	94,42° ±4,78° (90–109°)	106,28° ±9,14° (90–123°)	4,46° ±4,80° (0–19°)
Male athletes 31	94,81° ±5,36° (90–109°)	107,00 ±°8,35° (90–123°)	4,84° ±5,38° (0–19°)
Female athletes 26	93,96° ±4,02° (90–105°)	105,42° ±10,11° (90–123°)	4,00° ±4,06° (0–15°)

Table 2. The differences and the significance of the differences in the mean hip, knee, and ankle angles in different squats between male and female athletes, between squats with and without added weight

Samples of athletes being compared	The knee joint flexion angle	The hip joint flexion angle	The ankle joint dorsiflexion or extension angle (same as tibial shaft forward tilt angle)
1	2	3	4
	The differences and the significance of the differences by Student's test in horizontal squats		
Male and female athletes	2,25° Insignificant, p = 0,1153	3,21° Insignificant, p = 0,0829	2,24° Insignificant, p = 0,0692
All athletes without and with a barbell	*–4,56° Significant, p = 0,0013*	0,31° Insignificant, p = 0,8688	*–3,11° Significant, p = 0,0106*
Male and female athletes without a barbell	*4,71° Significant, p = 0,0232*	2,12° Insignificant, p = 0,4030	2,6° Insignificant, p = 0,1314
Male and female athletes with a barbell	–0,8° Insignificant, p = 0,6509	4,36° Insignificant, p = 0,1145	1,48° Insignificant, p = 0,3844
	The differences and the significance of the differences by Student's test in half-squats		
Male and female athletes	–5,66° Insignificant, p = 0,2718	5,59° Insignificant, p = 0,2880	–3,26° Insignificant, p = 0,0918
All athletes without and with a barbell	–10,33° Insignificant, p = 0,1327	–0,71 Insignificant, p = 0,9307	*–9,25 Significant, p = 0,0002*

1	2	3	4
The differences and the significance of the differences by Student's test in lunges			
Male and female athletes	1,81° Insignificant, p = 0,3049	1,79° Insignificant, p = 0,4190	1,58° Insignificant, p = 0,3811
All athletes without and with a barbell	*4,15°* *Significant, p = 0,0381*	–3,86° Insignificant, p = 0,1279	*4,37°* *Significant, p = 0,0326*
The differences and the significance of the differences by Student's test in Smith machine squats			
Male and female athletes	0,85° Insignificant, p = 0,5108	1,58° Insignificant, p = 0,5214	0,84° Insignificant, p = 0,5160



A – horizontal squats B – Smith machine squats C – half-squats D – lunges

Figure 1. Schematic drawing of the lower extremity joints mean angles in different squats

In addition to defining absolute values of flexion angles in the joints of the lower extremities in different squats, we also found that the knee joint flexion and the ankle joint dorsiflexion angles in a horizontal squat with a barbell are significantly larger (by a mean of 4.56° and 3.11° respectively) than in squats without added weight. The same trend was observed for half-squats, with an even greater difference. However, the last one is statistically significant only for dorsiflexion in the ankle joint (9.25° difference at p = 0.0002). Exactly the converse situation was observed in lunges when the knee joint flexion and ankle dorsiflexion angles are significantly lesser in barbell squats (by a mean of 4.15° and 4.37°, respectively). We also detected a slightly greater knee flexion angle in horizontal squats in men, which became significantly higher (by a mean of 4.71° at p = 0.0232) when using added weight (barbell). Thus, the knee flexion angle in horizontal barbell squats in male athletes is significantly larger than in female athletes. The hip joint flexion angle and the tibia forward tilt angle in horizontal squats in men are also greater than in female athletes, but the difference is insignificant.

Discussion

Our data correspond well to the study of powerlifters and weightlifters conducted by Wretenberg et al. (1996). However, we confirmed these with a larger sample of athletes with and without added weight, additionally evaluated tibia forward tilt, and investigated joint angles in the other types of squats also.

There are several methods for angles measuring in joints, so it is essential to know and understand which method the researcher uses to interpret the results adequately. Thus, in their generally interesting and valuable study, Lorenzetti et al. (2012) did not indicate either the method of measuring the angles they used or the depth of squatting. Regarding the angles by their values, we can guess that the angle between the shin and the thigh was most likely measured not with the neutral-zero method. In addition, we still do not have data on the depth of squats, and the study was conducted on students, not athletes. It is interesting to know the joint angles in the horizontal squats performed specifically by the athletes accustomed to performing it with the ideal technique regularly with weight and under a coach's control.

The study shows how different the lower extremities joint angles are among the athletes of strength sports with considerable experience in performing these variants of squats. We can use the means for computer-generated simulation of the tensile load in the joint anatomical elements during squats, which are part of the physical therapy and rehabilitation treatment of patients with the lower extremities joint injuries and diseases. We can also use these data to imitate squats in a direct stress machine for the tensile load test of anatomical structures and ligament grafts, strength evaluation of the fixation of grafts and fractures. Data on the angles range and differences between male and female athletes, between squats with and without barbells allow better adaptation of the physical therapy and rehabilitation program to the characteristics of injury, surgery, and functional purpose of patients.

Research limitations. A limitation of our study was the lack of strict standardization of athletes according to athletic disciplines and professional level. At the same time, we have restricted ourselves to strength sports and separately specified the joint angles in barbell squats and squats without a barbell. Another limitation of our study is the involvement of all athletes only for horizontal squats. Not all the athletes performed the other types of squats because of the later decision to include them in the study. Some athletes dropped out of further research due to injuries, illness, quarantine, social reasons, or not regularly practicing a particular type of squat. It could not be a model for their implementation and research.

Conclusions

Horizontal squats produce greater knee, hip, and ankle angles than half-squats, Smith machine squats, and lunges. There is a small but significant difference in the knee and ankle joint angles between the barbell and bodyweight horizontal squat and between the barbell and bodyweight lunges. The difference in join angles between male and female athletes is significant only for the knee flexion in horizontal barbell squats.

The exact mean joint angles and their extremes obtained in this study are essential for the further joint structural elements stress simulation studies with either a computational model or a direct stress machine.

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EVALUATION OF THE EFFECT OF PHYSICAL ACTIVITY ON THE PREVALENCE OF OVERWEIGHT AND OBESITY IN SCHOOL-AGED CHILDREN

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Abstract Introduction: Physical activity is one of the essential factors in maintaining health and healthy body weight. As the pandemic of overweight and obesity continues to grow, it is crucial that children follow the recommended standards for physical activity from an early age. Both overweight and obesity are associated with an increased risk of diseases such as diabetes, hypertension and cancer. Excess body weight in childhood favors the maintenance of this problem in adulthood.

Purpose of the study: The aim of the study was to evaluate the physical activity among school-aged children, to analyze individual components of body composition and to determine the influence of physical activity on maintaining normal body weight.

Material and methods: We undertook to assess of the frequency of participation of children in additional sports activities of 245 school-aged children (7–15 years) was examined and analyzed the body composition of the study participants, and then the correlation of the additional physical activity with the maintenance of normal individual components of body composition was calculated.

Results: 61% of childrens were characterized by normal body weight appropriate for their age. In the group of children declaring participation in extracurricular sport activities, the number of subjects with normal body weight was 65%, while in the group of subjects who declared no extracurricular activity of any kind, the percentage was 58%.

Conclusions: It turned out that the number of children engaged in physical activity outside of school is alarmingly low. The study found that children who participated in any extracurricular sports activity did not show a statistically significant difference in the frequency of maintaining a normal body weight ($p > 0.05$). However, on detailed percentage analysis, we can see a slight advantage among those who undertook additional physical activity.

Key words overweight, obesity, physical activity, children

Introduction

Obesity is one of the most alarming problems of the 21st century. Although the health consequences of obesity are widely recognized, the situation continues to worsen and the number of people with excessive body weight is increasing. The World Health Organization data show that between 1980 and 2008 the number of people whose body weight exceeds certain norms has doubled (Ritchie, Roser, 2017). Over the following years, the problem continued to grow and in 2016, 39% of men and women worldwide were overweight (Ritchie, Roser, 2017). Research conducted in 2011–2016 by the National Center of Health Statistics (NCHS, 2021) and Ogden et al. (Ogden, Carroll, Kit, Flegal, 2013, Ogden, Carroll, Fryar, Flegal, 2015) leads to similar conclusions (Figure 1), which shows that in 2011–2012 the problem of obesity or overweight affected 35% of citizens, in 2012–2014 the percentage was 37%, while in 2014–2016 it was already 40%. The situation in Poland is not optimistic either, as according to the Central Statistical Office in 2014, 30% of women and 44% of men were overweight and 15.6 women and 18% of men were obese (Zgliczyński 2017).

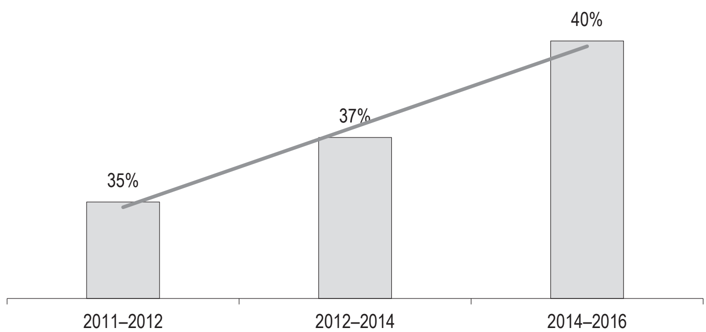

Figure 1. The changing number of overweight and obese people worldwide from 2011 to 2016

As the problem worsens, children and infants are also increasingly affected by excessive body weight. A 2016 report on the nutritional status of children worldwide reported that 40 million children under the age of five and 330 million aged 5–19 were overweight or obese (Di Cesare, Sorić, Bovet, 2019). Studies conducted in the United States show that the number of children who are overweight or obese, increases with age. Data presented by Kumar indicate that 22.8% of preschool children and 34.2% of school-aged children in the United States are overweight or obese (Kumar, Kelly, 2015). Both overweight and obesity carry a number of negative health consequences. Studies show that overweight individuals are significantly more likely to have health problems related to the respiratory system, cardiovascular system, musculoskeletal system, mental disorders, diabetes, and cancer (Bogucka, 2017; Bray, 2004, Brown, Kuk, 2015; Felson, Anderson, Naimark, Walker, Meena, 1988; Leitner et al., 2017; Lindström et al., 2003; Malone, Hansen, 2019; Margaret, 2011; Poirier et al., 2006; Rankin et al., 2016; Strohl, Strobel, Parisi, 2004).

Purpose of the study

The aim of the study was to assess the frequency of participation in extracurricular physical activity among school-age children, to analyze individual components of body composition and to determine the influence of additional physical activity on maintaining normal body weight. A hypothesis was formulated that children who participate in additional physical activity are more likely to maintain normal body weight than inactive children.

Materials and methods

The study was approved by the Bioethics Committee at the Medical University of Karol Marcinkowski in Poznań, resolution number 427/17. The study was conducted in an elementary school in February 2020. Any child in grades 1–8 whose parents provided consent was eligible to participate. Written consents were provided to each parent. 245 children participated in the study. The mean age of the subjects was 10 years (SD = 2.2). There were 124 boys and 133 girls among all participants. Of all the children surveyed, two were disabled. The questionnaire consisted of questions about the place of residence in the country or in the city, then about the participation in additional extracurricular sports activities and in case of declaration of participation there was a request to indicate what kind of activity it was. 76% of the respondents lived in the city and 24% in the country. The questionnaire provided information that 40% of people participating in the study declared participation in the above mentioned sport activities. 60% of people declared that they do not participate in any extracurricular sport activities. Among the chosen forms of extracurricular physical activity, there were sports such as: soccer (43%), gymnastics (19%), dance (9%), horse riding (6%), martial arts (5%), athletics (5%), badminton (5%), table tennis (3%) and others (3%).

The Tanita BC-418 MA segmental body composition analyzer was used for detailed body composition analysis. This device uses a non-invasive method of electrical biompedance. It consists in measuring the total resultant electrical resistance of the body, which is the derivative of resistance (passive resistance) and reactance (active resistance) using a set of surface electrodes connected to a computer analyzer and using a current of a given frequency and intensity (Lewitt, Mądro, Krupienicz, 2007). Individual components of body composition such as body weight (kg), BMI (weight/height^2), adipose tissue (%, kg), fat-free tissue (%, kg), muscle mass (%, kg), and water (%, kg) were analyzed.

All calculations and data visualization were performed using Statistica 13 package, the administrator of which is the Academy of Physical Education in Poznań. In addition, centile grids, created during the OLA and OLAF project conducted in Poland in 2007–2013 (Kułaga et al., 2010, 2013), were used to interpret the BMI (Body Mass Index) score.

Results

After collecting all data, the mean, maximum, and minimum values were calculated for selected body composition components (Table 1).

Table 1. Results of body composition measurements of participants

Selected components of body composition	Mean (M)	Standard deviation (SD)	Minimum value (min)	Maximum value (max)
Height (cm)	145.8	14.2	115.0	186.0
Weight (kg)	40.4	15.5	18.0	103.1
BMI (weight/height^2)	18.5	4.4	12.5	38.3
Adipose tissue (%)	22.8	6.6	11.5	47.1
Muscle mass (%)	74.0	6.5	50.6	85.3
Water (%)	56.6	4.8	38.7	64.8

After analyzing the body composition components of 245 children, we found that 61% of them were characterized by normal body weight appropriate for their age. Overweight was present in 19% of the subjects, while obesity was present in 8% of the subjects. Among those classified as "underweight" were 12% of the children (Figure 2).

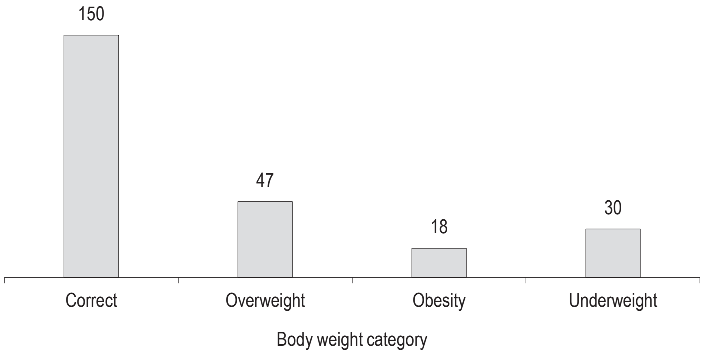

Figure 2. Distribution of individual body mass categories among all children examined (n = 245)

A Chi-square test was used to assess the relationship between the prevalence of abnormal or normal body weight and participation in additional sports activities. The relationship was not statistically significant ($p > 0.05$). In the group of children declaring participation in extracurricular sport activities, the number of subjects with normal body weight was 65%, while in the group of subjects who declared no extracurricular activity of any kind, the percentage was 58%. In both the active and inactive groups, the percentage of overweight subjects was 20%. A difference was observed among the percentages of obese and underweight subjects. The portion of active children classified as obese was 6%, while among inactive children, 8% of them were obese. The underweight respondents were 9% for the active group and 14% for the inactive group, respectively (Figure 3).

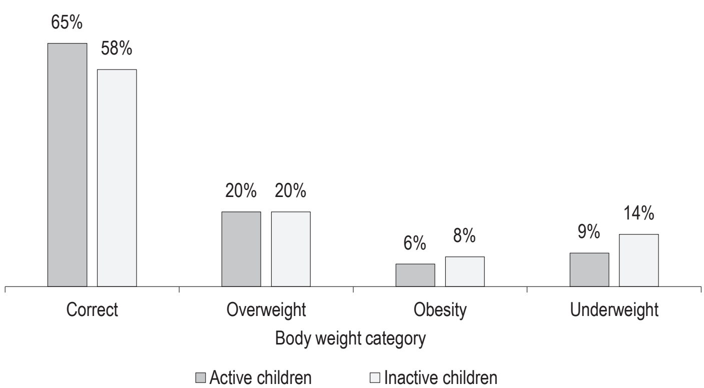

Figure 3. Percentage of subjects classified into each weight category (n = 245)

The lack of statistical significance in the above analysis may indicate that additional physical activity alone is not sufficient to maintain a healthy body weight. However, as we can look at above (Figure 3) the percentage analysis shows that those who participated in additional physical activity were more likely to maintain a normal body weight and were less likely to be overweight or underweight.

Discussion

The current World Health Organization (WHO) recommendation for the minimum recommended level of physical activity in children aged 5–17 years is 60 minutes of moderate activity per day. Daily activity should include aerobic exercise and it is additionally recommended that children should do strength training, strengthening the whole body, at least 3 times a week (Bull, Al-Ansari, Biddle, 2020). Taking into account the above recommendations it can be concluded that the percentage of 40% of students participating in extracurricular sport activities of students participating in extracurricular sports activities is a very alarming figure. In a study conducted in 2005–2006, Chabros et al. (2008) evaluated the level of physical activity in 1,054 students aged 11–15 years. They found that 38.6% of boys and 34.7% of girls participated in extracurricular sports activities. In the cited study, it was noted that the frequency of participation in extracurricular sports activities decreases with the age of students (Chabros et al., 2008). Similar results were presented by the Australian Institute of Health and Welfare, indicating that the percentage of children meeting recommendations for minimal physical activity decreased with age, from 61% at ages 2–5 to 26% at ages 5–12 and to 7.9% at ages 13–17 (McCarthy et al., 2021). As shown by studies conducted in the United States, the situation there looks much worse than in Poland, as 20% of the examined children meet the minimum level of physical activity (DiPietro et al., 2019). Insufficient levels of physical activity among children may be one of the components contributing to the ever-increasing problem of overweight and obesity in this age group. Numerous studies indicate that the problem of abnormal body weight in school-aged children is a common phenomenon (Chabros et al., 2008; McCarthy et al., 2021; DiPietro et al., 2019; Weker et al., 2017). However, it should be noted that the occurrence of overweight and obesity can also occur at earlier ages. A 2016 study conducted by Weker et al. (2017) on more than 1050 Polish children found that nearly 10% of children aged 1–3 years were overweight or obese. Weker also reports that 18% of the children studied are at risk of excessive weight in the future, and this is due to poor nutrition (Weker et al., 2017). The data presented in the above results section presents that 20% of the examined school-aged children, were overweight and 7% were obese. In the previously mentioned study by Chabros et al. (2008) the weight level of the subjects was also assessed. 18.4% of boys and 11.9% of girls were overweight, while obesity was found in 2.8% of boys and 3.4% of girls. Gołąbek and Majcher (2019) also undertook to assess body weight among school-aged children. They checked the prevalence of overweight and obesity among girls and boys aged 11–12 years. Gołąbek and Majcher study yielded similar results to those presented above. Overweight was present in 23% of both girls and boys (Gołąbek, Majcher, 2019). Obesity was present in 6% of girls. A significant discrepancy was observed only in the case of overweight boys, since the study by Gołąbek showed obesity in 21% of boys (Gołąbek, Majcher, 2019). Few Polish authors have attempted to show the correlation between the level of physical activity in children and the prevalence of overweight and obesity. The study by Bojar, Wojtyła and Owoc (2010) showed that children who participated in all or most of the physical education classes were more likely to have a normal body weight. Among those who participated in all or almost all PE classes, obesity was present in 11%, while in those who missed more PE classes, the percentage of children with obesity was 21%. In a study conducted in 2020 by Pysna et al., 1,073 elementary school children were examined. This study also aimed to evaluate the level of physical activity of children and its effect on their body weight. They found that children who spend more time on physical activity are more likely to have a normal body weight (Pyšná, 2020). However, there is not much work evaluating the relationship between physical activity and body weight, so further research in this area is needed.

Conclusions

1. The number of children taking up extracurricular physical activity (40% of examined children) is definitely too low.

2. 61% of examined children were characterized by normal body weight and 39% were characterized by abnormal body weight.

3. The hypothesis that children who participate in additional physical activity are more likely to maintain normal body weight than inactive children was unconfirmed.

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DETERMINANTS OF THE PROLONGATION OF THE YIPS IN GOLFERS: THE ROLES OF SOCIAL SUPPORT AND OVERCOMMITMENT TO SPORT

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Abstract The yips are the loss of automated and finely controlled motor behavior in sport, affecting many golfers. Although studies have examined their causes and treatment, the social and psychological factors that contribute to their duration in golfers remain unknown. This study examined whether overcommitment and social support are related to prolonged symptoms of yips. Participants included 54 yips-affected golfers who completed measures to identify those who were overcommitted and explore their experiences with the yips and social support. Although there was a significant relationship between prolonged symptoms of the yips and overcommitment, social support was not related to its duration. These results contribute to the understanding of the prolongation of the yips in golfers and may apply to players in other sports.

Key words movement disorder, social support, overcommitment, golf, multiple logistic regression analysis

Introduction

Many golfers globally are affected by a movement disorder known as the yips (Heron, Bilalić, 2022). The yips influence the execution of automated and finely controlled motor behavior in sports, such as golf, baseball, table tennis, petanque, darts, and cricket (Bawden, Maynard, 2001; Clarke, Sheffield, Akehurst, 2015; Lenka, Jankovic, 2021). Although yips in golf occur during putting (Philippen, Lobinger, 2012), they have also been observed in driving and chipping (McDaniel, Cummings, Shain, 1989). The yips symptoms in golf include jerks, tremors, and freezing of the stroke (Smith et al., 2000). Smith et al. (2003) reported "The yips phenomenon can be a source of frustration and cause people to give up the game." Estimates of the prevalence of the yips in golf vary considerably. One survey of golfers revealed that, among the 441 respondents, 123 (28%) had the yips (McDaniel et al., 1989). A later survey found that 453 (53.5%) of 846 golfers acknowledged previously having the yips (Smith et al., 2000).

Due to the high risk and prevalence of the yips, research has focused on their etiology – primarily potential psychological and neurological factors – and treatment strategies. Identification of psychological factors, including choking under pressure (Bawden, Maynard, 2001), perfectionism (Roberts, Rotheram, Maynard, Thomas, Woodman, 2013), and reinvestment (Klämpfl, Lobinger, Raab, 2013), led to studies of psychological treatments demonstrating the effectiveness of solution-focused guided imagery (Bell, Thompson, 2007; Bell, Skinner, Fisher, 2009), emotional freedom techniques (Rotheram, Maynard, Thomas, Bawden, Francis, 2012), and cognitive behavior therapy (Milne, Morrison, 2015). Associated neurological factors comprise dystonia (Ioannou, Klämpfl, Lobinger, Raab, Altenmüller, 2018), cramping (Sachdev, 1992), and tremors (Dhungana, Jankovic, 2013). Research on neurological treatment strategies includes botulinum toxin injections (Dhungana, Jankovic, 2013), N-methyl-D-aspartate receptor antagonist drugs (Ringman, 2007), acupuncture (Rosted, 2005), self-instruction (Lobinger, Klämpfl, Altenmüller, 2014), relaxation (Lobinger et al., 2014), and performance routines (Lobinger et al., 2014).

Symptoms of the yips can be very serious and chronic (Bawden, Maynard, 2001; Lobinger et al., 2014); therefore, it is crucial to clarify their etiology to prevent the onset of symptoms and develop treatment strategies. However, it is equally important to shed light on why athletes developing the condition take such a long time to improve by identifying factors related to its prolongation. Determining the causes related to the yips' duration is of paramount importance for various reasons. Researchers (e.g., Kudo, 2008) have revealed an etiological phenomenon wherein the excessive repetition of a movement in a sport leads to the fusion of parts of the sensorimotor cortex with neighboring areas of the cerebral cortex. However, it is essential for golfers to repeat movements and train iteratively to become elite athletes, win championships, and generally improve their skills. Philippen (2012) found that golfers also engaging in racquet sports, such as tennis and badminton, may overuse their hands and arms in those activities, possibly triggering development of the yips. This finding suggests that the development of the yips may involve unavoidable movements and behaviors both related and unrelated to golf. Moreover, baseball players affected by the yips have reported being humiliated by their peers when they miss a throw or throw wildly, triggering the development of affliction (Mukai, 2016). Therefore, the yips' development may involve the response or assessment of a mistake related to performance in the sport.

Considering the existing research findings on the etiology and prevalence of the yips, all golfers are at risk of suddenly developing the condition. Indeed, when golfers first suffer the yips, they report that it happens suddenly (Bawden, Maynard, 2001). Consequently, it is imperative to not only verify the etiology and treatment strategies of the yips, but also explore the factors involved in its prolongation, given that athletes who develop the condition may suffer from severe symptoms for a long period of time (Bawden, Maynard, 2001; Lobinger et al., 2014). Clarifying these factors will enable concrete measures to deal with the yips because improving these factors may help to improve the condition.

Although previous research has been conducted on the etiology and treatment strategies of the yips, only two studies have explored factors related to the yips' prolongation. Psychological factors such as attentional narrowing

(Mukai, Koga, 2017) and holding onto various things, such as the defensive (positions in baseball) and pulled-back position in throwing (Mukai, Koga, 2019), have been shown to prolong the yips. However, each study only included 15 baseball players. Consequently, it is imperative to conduct research on the yips' prolongation in golf because many players have been affected by it.

Mukai and Koga (2017, 2019) demonstrated that various psychological factors affect the yips' prolongation, suggesting that golfers' attitudes toward golf are relevant to the possible relationship between psychological factors and prolongation. Some golfers are high attached to golf and are unwilling to quit it. When these golfers develop the yips and are suddenly unable to perform movements they have always done competently, one may assume that this will have an adverse effect on them, and they will take it seriously. Furthermore, they may find it impossible to adaptively cope with the yips, thus leading to its prolongation. Consequently, the present study examined overcommitment, which refers to the psychological characteristics of individuals who are overly devoted to specific things, to explore whether a golfer's attitudes, thoughts, and relationship to golf are related to the yips' prolongation. Joksimovic et al. (1999) defined overcommitment as "a set of attitudes, behaviors, and emotions reflecting excessive striving in combination with a strong desire to be approved and esteemed." Tsutsumi et al. (2008) revealed that individuals characterized as being overcommitted tend to dedicate themselves to work activities and amplify their efforts beyond what is normally considered appropriate. Regardless of their abilities, states, and conditions, overcommitted individuals exhibit excessive effort or commitment to acquiring a high evaluation from their peers. Additionally, overcommitment to work is known to cause musculoskeletal pain (Joksimovic, Starke, Knesebeck, Siegrist, 2002), burnout (Bakker, Killmer, Siegrist, Schaufeli, 2000), depression, and cardiovascular disease (Peter et al., 1998).

Overcommitment has also been explored in sports psychology (e.g., Yates, Shisslak, Crago, Allender, 1994). Maladjustments, including eating disorders, psychosomatic disorders, and burnout, in athletes have been linked to overcommitment (Heidari, 2013; Matsui, 2015a; Shisslak, Crago, 1999). Yips-affected athletes have expressed excessive concern about others' evaluations; one athlete related, "I was too worried about what others were thinking and not worrying about myself" (Bawden, Maynard, 2001). Rotheram (2007) found that athletes tended to exemplify their excessive commitment to sport by asserting that they were obsessed with their particular sport. Furthermore, Silva (1994) revealed that baseball players' overcommitment may continue after development of the yips; they fear throwing and are unable to sleep at night as they ruminate on their performances and recall pitches when trying to sleep.

In light of these studies, we hypothesized that a high overcommitment tendency could prolong the yips. Such reactions and assessments from others of an athlete's performance may be factors in development of the yips, because the environment may play a key role in how yips-affected athletes cope with the affliction. Thus, if every mistake made by athletes with the yips is met by harsh criticisms and/or negative responses from coaches and teammates, the athletes may find themselves in a vicious cycle that may exacerbate and prolong the yips' symptoms, whereas adaptive environments in which coaches and teammates accept and support yips-affected athletes may facilitate or positively affect their recovery. Hence, we also explored social support in this study. This concept encompasses various forms of aid and assistance provided by those in the athletes' surroundings (Barrera, Sandler, Ramsay, 1981). Studies have demonstrated that social support is important to health maintenance and recovery from illness and injury (Bianco, 2001). Hence, the present study examined the potential relationships between the yips' prolongation for golfers and their social support (from coaches, other golfers, friends, and family) and between prolongation and overcommitment to the sport.

However, no universal definition of the yips has been established, possibly because of the affliction's numerous related factors. Divergent descriptions exist, including "a psycho-neuromuscular impediment affecting the execution of fine motor skills during sporting performance" (Clarke et al., 2015), "jerks, tremors, or a freezing of the putting stroke, which at the very least can add several strokes per round of golf" (Bell, Thompson, 2007), and "a movement disorder such that movements one has been able to do can no longer be performed because of psychological factors" (Shinmura, 2018). In this study, the yips are defined as a long-term movement disorder occurring in the execution of automated and finely controlled motor behavior in a sport, due to multiple etiological factors, such as psychological and neurological factors.

Material and methods

Participants

We asked representatives of several golf organizations (association staff, team assistants, and captains) to recruit golfers, and 346 professional and amateur male golfers responded to three study questionnaires and one demographic questionnaire. However, 37 were excluded for incomplete questionnaires, leaving a total of 309 golfers (age, 16–75 years, mean = 35.89, standard deviation [SD] = 14.24; golf experience, mean = 21.66 years, SD = 11.18).

Of the 309 golfers, those included in the analysis were selected by the following procedures. According to our definition of the yips and the criteria established by Sachdev (1992) and Roberts et al. (2013), we developed five inclusion criteria: (1) at least five years of experience playing golf; (2) apparent abnormalities, e.g., spasm, jerk, tremor, and/or freezing of movement when executing fine golfing strokes, such as putting and chipping; (3) a sudden inability to perform a motion that was previously very natural; (4) symptoms had continued for at least 1 year; and (5) noted abnormalities in the execution of fine golfing strokes were not the result of an obvious physical disability or sports injury. The responses to the four questionnaires were used to determine whether these five criteria were satisfied. Accordingly, 54 (17%) of the 309 golfers had the yips; 233 golfers who did not develop the yips and 22 other golfers who did not meet the inclusion criteria were excluded. Biometrical and yips-related data of the 54 golfers are presented in Table 1. Among these, we analyzed the data of those in the top 25% (long-term yips-affected group; n = 14) and bottom 25% (short-term yips-affected group; n = 13) according to the number of years they had the yips (Table 1). It should be emphasized that, although the golfers were divided into short-term and long-term yips-affected groups, to distinguish between those with short-term and long-term effects clearly, only those with the shortest and longest experiences were targeted for analysis.

Table 1. Biometrical and the yips-related data of golfers with long-term and short-term effects

Group	N	Age, years Mean (SD)	Golf experience, years Mean (SD)	Duration of the yips years Mean (SD)
All yips-affected golfers	54	36.70 (13.70)	23.41 (10.14)	5.24 (5.32)
Long term yips-affected group	14	41.64 (10.43)	17.79 (8.27)	12.43 (5.73)
Short term yips-affected group	13	34.77 (16.65)	21.46 (11.95)	1.04 (0.09)

SD, standard deviation.

Measures

All the respondents were required to answer three questionnaires: (1) a survey about the yips, (2) a scale of overcommitment to sport, and (3) a social support survey. They also completed a demographic survey related to their golf experience: years of experience, starting age, competition level, and medical-related issues, including experiences of neurological disorders (i.e., dystonia, Parkinson's disease), hospital visits, and medications they have taken to treat psychiatric illnesses.

Questionnaire on the yips

The first questionnaire assesses whether the participants had the yips by asking about experiences with symptoms, such as a sudden inability to synchronize their body and mind, spasms, freezing, and inability to control the ball. Those who responded in the affirmative provided written responses to further questions related to the yips, including their age when they developed the yips, specific symptoms, level of golf skill when symptoms first occurred, duration of the yips, degree of suffering from the condition, causes of its development, and how they coped with the affliction.

The scale of overcommitment to sport

We adapted a scale developed by Matsui (2015b) to measure the tendency of excessive commitment to golf-related extracurricular activities by substituting the single word *golf* for *extracurricular activities* in the survey. The revised scale comprises one factor and six items, which the respondents assess on a scale from 1 (*not applicable at all*) to 5 (*very applicable*). An example item is “I want to make time for golf even if I cut back on time for other things in my life.” Total scores range from 6 to 30, with higher scores indicating a greater tendency for overcommitment. Because we changed the wording and content of some of Matsui's (2015b) scale items, we confirmed the factorial structures and reliability of the scale. First, exploratory factor analyses confirmed the one-factor structure following the original scale development study that deemed it reliable with Cronbach's α of 0.81 (Matsui, 2015b). In the present study, reliability was confirmed with Cronbach's α of 0.87. The results indicated that the factor structure and internal consistency were appropriate.

Social support scale

Fukuoka's (1997) scale measures the amount of social support an individual receives from people around them. We modified its wording to develop a nine-item scale aligned with the present study's subject and purpose. The nine items focus on social support in various situations, such as “When I am depressed, someone cheers me up,” assessed on a scale from 1 (*not applicable at all*) to 5 (*very applicable*). Total scores range from 9 to 45; higher scores mean more perceived support from their peers. The factorial structure of the revised scale was verified using exploratory factor analysis; the one-factor structure of Fukuoka's (1997) study was confirmed. Cronbach's α was 0.80 for Fukuoka's scale and 0.95 for the scale we adapted for this study. The results revealed that the factor structure and internal consistency were appropriate.

Procedures

We provided information about the study's purpose, protection of the participants' personal information, and an overview of the yips to the golfers before administering the surveys. Furthermore, participants were advised that they could withdraw from the study at any stage. Those who gave their informed consent and understood the study and the yips were asked to participate. To administer the questionnaire, the first author and a survey collaborator under the author's direction employed the collective survey method. To ensure the collection of a sufficient amount of data, we administered surveys from 2018 through 2019 to golfers who had the yips and met the inclusion criteria.

Analysis

We used multiple logistic regression analysis to evaluate the extent to which overcommitment and social support predicted the yips' prolongation in golfers; $p \leq 0.05$ was considered statistically significant. The models' goodness of fit was assessed by employing the Hosmer-Lemeshow Test, Cox and Snell's R^2 square, and Negelkerke's R^2. Given that the dependent variables were categorical, data distribution normality was not tested.

Ethical considerations

This study was conducted in accordance with the tenets of the Declaration of Helsinki. Ethical clearance was not sought because the sample population comprised healthy individuals without mental issues and data were gathered using a short, low-burden questionnaire survey (15-min completion time). The survey was administered only after obtaining informed consent from the participants, which included: 1) responses are voluntary and freedom of participation is guaranteed; 2) the survey is anonymous and the respondent will not be identified; 3) there will be no disadvantage if the respondent refuses to answer or discontinues the survey; 4) the data obtained will not be used for any purpose other than research and will be quantified after collection, with no personal information disclosed; 5) the data will be stored and managed appropriately by the principal investigator; and 6) if the participant complains of mental illness during or after the study, a clinical psychologist or psychiatrist will be consulted.

Results

The results from the logistic regression revealed that the predictors of the full model were significant, $\chi^2(2.27) = 6.47$, $p = 0.03$, indicating that the model was able to distinguish golfers who had the yips for a long time from those afflicted for a short period. The model explained between 21.3% (Cox and Snell's R^2) and 28.4% (Nagelkerke's R^2) of the variance in the rate of the prolongation of the yips and correctly classified 70.4% of the cases. Furthermore, the Hosmer-Lemeshow test indicated a good model fit to the data ($\chi^2(7) = 6.52$, $p = 0.48$). In Table 2, the regression coefficients (β), standard error (SE), Wald statistics, significance level, odds ratio [Exp(β)], and 95% confidence intervals for the odds ratio for each predictor are presented. As shown in Table 2, an examination of the predictors/independent variables revealed that although overcommitment was significant (β = 0.18, Wald(1) = 4.19, $p = 0.04$, Exp(β) = 1.20), social support was not significant (β = –0.03, Wald(1) = 0.43, $p = 0.50$, Exp(β) = 0.96). Consequently, the possibility of predicting the prolongation of the yips in golf was only demonstrated by overcommitment. Biometrical and yips-related data for each group are displayed in Table 2.

Table 2. Logistic regression analysis predicting likelihood of prolongation of the yips in golfers

Predictor	β	*SE*	Wald	*p* Value	Exp (β)	95% CI for Exp(β)
Overcommitment	0.18	0.08	4.19	0.04	1.20	1.00 to 1.42
Social Support	–0.03	0.05	0.43	0.50	0.96	0.86 to 1.07
Constant	–2.71	2.74	0.98	0.32	0.06	

Hosmer-Lemeshow Test: Chi-sqare = 6.47, p = 0.03; Cox and Snell R^2 = 0.21; Nagelke R^2 = 0.28.

β = regression coefficient; the mathematical weightings of the explanatory variables in the equation.

SE = standard error; estimated precision of the coefficients.

CI = confidence interval.

Wald = Test statistic for testing whether the partial regression coefficient is 0 or not and a large value of Wald means that the hypothesis is rejected.

Discussion

In the present study, multiple logistic regression analysis was performed to clarify the factors associated with the yips' prolongation in golf. While the dependent variable was the prolongation of the yips in golf (long-term and short-term yips-affected groups), overcommitment and social support were the independent variables. The results revealed that, although overcommitment significantly predicted the yips' prolongation in golf, social support was not significant.

First, the main findings show that golfers with higher tendencies toward overcommitment to golf exhibited excessively strong thoughts about golf, such as “If I were to quit golf, I would not find any meaning in life,” “The center of life is golf,” and “I am not interested in anything other than golf,” and are likely to suffer relatively long-term yips' symptoms. For golfers who have higher tendencies toward overcommitment to golf, upon developing the yips and being unable to perform as before, or if they get a sense of crisis indicating they may not be able to continue playing golf, they will not give up immediately but will try to improve the dysfunctions caused by the yips at all costs. Seeking improvement, they naturally go through a variety of trials and errors. Previous studies have shown that yips-affected golfers will search for any way to somehow overcome the yips (Marquardt, 2009) by engaging in more training or practice (Oikawa, 2019). In this process, they tend to be excessively attentive to, or try to consciously control, automated movements (Bennett, Rotherham, Hays, Olusoga, Maynard, et al., 2016; Masters, Maxwell, 2008). Hence, it can be inferred that these tendencies are particularly strong among golfers with high tendencies toward overcommitment to golf.

Additionally, prior research has suggested that individuals characterized as “overcommitted” tend to dedicate themselves to work activities and amplify their efforts beyond what is normally considered appropriate (Tsutsumi et al., 2008). Furthermore, rather than overcoming the yips, increased training and practice and excessive attention to movements often exacerbate the yips' symptoms (Marquardt 2009; Oikawa, 2019).

Given that neurological factors may be involved in the yips' development (Ioannou, Klämpfl, Lobinger, Raab, Altenmüller, 2018; Lenka, Jankovic, 2021), an imbalance between physical and mental fatigue, excessive attention to movements impaired by the yips, and increased practice times may trigger an exacerbation of contributing neurological problems. Thus, the yips' symptoms are prolonged. Essentially, overcommitment to a sport may trigger a neurological response making yips-affected athletes overly conscious of their movements or encouraging excessive practice, thereby further prolonging the yips.

These theories could explain the relationship between the yips' prolongation and overcommitment to golf. Previously, overcommitment was shown to be associated with greater levels of anxiety and depression (Mark, Smith, 2012). More importantly, other studies indicated that psychological factors, such as anxiety, embarrassment, fear, frustration, insecurity, shame, and stress potentially exacerbate the symptoms and dystonia associated with the yips (Bawden, Maynard, 2001; Bennett, Hays, Lindsay, Olusoga, Maynard, 2015; Byl, 2004; Jetjumnong, Norasetthada, 2022; Marquardt, 2009; Sachdev, 1992; Smith et al., 2003). Similarly, Bennett et al. (2015) reported that continued negative emotions relating to the yips eventually lead to Lost Move Syndrome (e.g., fear, embarrassment, frustration) in addition to increased feelings of self-hatred, self-doubt, and a loss of confidence. Additionally, Bell et al. (2009) reviewed previous studies on psychophysiological models and highlighted that the fear, anxiety, worry, and perceived threat accompanying the yips can lead to a negative cycle of doubt and muscle tension that also may prolong the symptoms. These findings infer that those golfers with higher tendencies toward overcommitment to golf may have prolonged the yips' symptoms. From a different vantage, the association between the yips' prolongation and overcommitment seen in the present study suggests that golfers who are less inclined to overcommit to golf are less likely to suffer from prolonged yips' symptoms and their symptoms may improve more quickly compared to those who are likely to overcommit.

Studies of the yips in golfers have shown that some athletes who removed themselves from the game for some time experience improved symptoms (e.g., Marquardt, 2009). Mukai (2016) argues that when athletes have the yips, repeatedly performing the movements in which the symptoms are appearing may worsen the symptoms. Moreover, Mukai (2016) mentions that athletes can relax their minds and improve their yips by temporarily stopping the movements during which the yips symptoms appear. Considering these previous studies, temporary physical or psychological separation from the sport or the movement in which the symptoms of the yips are appearing may be a way to avoid the yips. Attempts to overcome the yips, such as undergoing cognitive behavior therapy (Milne, Morrison 2015), participating in psychological education programs with image instruction (Solution-Focused Guided Imagery: Bell, Thompson 2007; Bell et al., 2009), changing clubs, and modifying one's swing, may be crucial. However, when the yips' symptoms emerge, it may also be important for athletes to temporarily forget about the sport or the yips by becoming immersed in other hobbies or activities or to work hard on improving skills that could help avoid the symptoms to appear, or removing themselves physically and mentally from the sport or the movements that provoke the symptoms. Conversely, many studies have shown that commitment to sport plays an essential role in improving sporting skills, abilities, and motivation (Casper, Andrew, 2008; Chu, Wang. 2012; Hollenbeck, Williams, Klein, 1989; O'Neil, Hodge, 2020; Woods, Dunne, McArdle, Gallagher, 2020). Therefore, while an adaptive commitment to golf is important and beneficial, it is speculated that excessive commitment may reduce mental comfort, narrow perspectives, narrow the range of options for dealing with the yips, and increase the likelihood of prolonged yips.

Another key finding was that there was no significant relationship between social support and yips' prolongation in the golfers. While these findings may simply suggest that support from coaches, other golfers, friends, and family are not significant influential factors in prolonging or early improvement of the yips, other rationales can be deduced from these findings. First, we speculate that specific golf characteristics may be involved. Unlike team sports, such as baseball and soccer, golf is an individual sport. Essentially, a golfer practices and may play games alone, without belonging to a specific team or organization. Many professional golfers do not have a specialist coach but may spend their days polishing their skills on their own by practicing and playing games. Therefore, even if they develop the yips, many golfers may not receive sufficient social support and may spend days struggling on their own. Additionally, because there are few experts with a wealth of knowledge about the yips to provide sufficient support to help golfers with it, golfers may find it difficult to find someone who can respond to their needs even if they want to seek advice or support for the condition.

For example, if a person who lacks knowledge about the yips interacts inappropriately with yips-affected athletes, the yips' symptoms may worsen or be prolonged. Several previous studies have shown that either psychological factors (anxiety, embarrassment, shame) or excessive attention to movements with symptoms of the yips can exacerbate these symptoms (Bennett et al., 2016; Smith et al., 2003). It can be inferred that inappropriate interactions by those who lack knowledge of the yips, even if the interactions are intended to help yips-affected athletes, can promote factors that may exacerbate the symptoms. Therefore, it is insufficient to simply receive support from coaches, other athletes, friends, and family; however, if they do not receive appropriate support from those who have sufficient knowledge about the yips, the improvement of the yips' symptoms may not be accelerated.

There was no difference in social support between the long-term and short-term yips-affected groups. Future researchers should conduct intervention studies with yips-affected athletes in various sports to clarify the relationship between social support and the yips' prolongation and determine if there is a difference in the duration of the yips' symptoms between athletes who receive appropriate support and those who do not. Additionally, we used Fukuoka's (1997) scale that measures the amount of social support an individual receives from people around them; however, this scale was originally developed to measure support in daily life and not in sports. Therefore, it is highly likely that this scale cannot properly measure the amount of social support that yips-affected golfers received from surrounding athletes and coaches in the present study.

Conclusions

Although the results of this study revealed no significant relationship between social support and the duration of the yips' symptoms, there was a significant relationship between prolonged symptoms and overcommitment. Golfers who exhibit a higher tendency of overcommitment to golf tend to have relatively long-term yips' symptoms, while those who do not tend to overcommit are unlikely to have the yips for prolonged periods and/or tend to see improvement in their symptoms. Such knowledge about the relationship between overcommitment and the yips' prolongation can help elucidate how to cope with the yips. In other words, excessive commitment to sports may prolong the appearance of symptoms. Thus, as a countermeasure, suppressing excessive commitment to sports may improve the yips' symptoms.

Moreover, because the yips are a movement disorder with severe chronic symptoms that are not easily completely cured, one may assume that athletes who develop the yips could be successful if they accept it and consciously think they can still perform. Therefore, they may try various coping methods and physically and mentally force themselves to recover quickly and completely. However, because of their enthusiasm for a prompt and complete cure of the yips, excessive awareness of their swing or repeated changes may exacerbate the yips' symptoms and prolong the condition. Therefore, it may be necessary to stop playing the particular sport shortly after the yips' symptoms appear, play other sports occasionally, and/or become immersed in a hobby to manage the yips successfully. Future research is recommended to clarify the factors prolonging could yips and apply the knowledge obtained to implement effective interventions to improve and treat the yips.

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NUTRITIONAL STRATEGIES OF YOUNG, PHYSICALLY ACTIVE RESIDENTS OF WROCŁAW

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Abstract Proper diet is a well-established factor influencing the effectiveness of training. To assess the knowledge of young sportspeople from Wrocław about sport nutritional strategies an online survey was distributed to Wrocław sport schools and clubs. The respondents were asked to answer questions regarding their sport activity, diet and the knowledge of nutrition strategies. The answers were then compared with the recommended strategies of International Society of Sports Nutrition (ISSN) and other research on this topic.

147 answers were analyzed. 38% of the respondents modified their diet due to training. Their most popular strategy was an additional pre-workout meal. In the group that did not modify the diet, the majority (82%) heard of some sport nutrition strategy. 52% of the respondents consumed a protein peri-workout meal. Estimated 30% consume the amount of protein recommended by ISSN.

Percentage of young sportspeople adjusting diet to training seems to be low, taking into account both established importance of such proceedings and awareness of sport nutrition strategies in this group. Interestingly, more men than women do so. Group of respondents following well-documented ISSN recommendations is comparably modest. Perhaps the topic of nutrition strategies should be given more emphasis in schools and sport associations.

Key words sports nutrition, macronutrients, performance, young athletes, diet

Introduction

According to a report prepared by the Polish Central Statistical Office, as of 2016 22% of Poles engaged in any sport activity on a regular basis, meaning at least 1–2 times weekly (GUS, Departament Badań Społecznych i Warunków Życia, 2017). The level of physical activity was significantly higher among teenagers and young adults. 40.7% of people aged 15–19 and 27.7% of 20–29 years old performed a sport activity regularly. Therefore it is likely that young people also make an important part of all Poles exercising with an aim of achieving specific progress. The progress can be understood variously, depending on the sport discipline. It can refer for example to the number of repetitions of a given exercise or the time needed to cover a distance running, swimming, or cycling.

The training itself is only one of the factors influencing sport progress. The diet accompanying trainings is of great importance too, as was proved by the results of numerous scientific studies: Grant et al. (2015); Rossi et al. (2017), Wenzel, Valliant, Chang, Bomba and Lambert (2012), Daniel, Jürgensen, Padovani, Juzwiak (2016), Kavouras et al. (2012). It was proven that the diet accompanying training can affect both the body itself, for example by accelerating muscle mass gain, and sport performance.

Since young Poles are on average more physically active than the other age groups, and nutrition in sport is of paramount significance, it is important to explore the topic of nutritional strategies of younger sportspeople.

Purpose

The aim of this article is to assess the level of awareness of young athletes from Wroclaw of various nutritional strategies including those recommended by the International Society of Sports Nutrition (ISSN), to provide an insight in how sport activities affect the nutrition of young sportspeople and to draw attention of athletes to the importance of proper nutrition in achieving better results in sport.

Methods

An anonymous questionnaire, which included questions about the diets used by the respondents, was created to obtain information about the nutrition of physically active residents of Wrocław. The questionnaire was made available by e-mail to Wrocław sports schools, sports clubs and other peers who regularly practice sports. The collected data was compared to the current ISSN recommendations (Kerksick et al., 2017) and conclusions from other scientific articles on a similar subject. After analyzing the similarities and differences between the collected information and the recommendations the conclusions were drawn.

In order to emphasize the importance of diet in the context of training, the PubMed and Google Scholar databases were searched for articles on a given topic using the keywords: “Sport”, “Exercise”, “Nutrition”, “Timing”, “Macronutrients”, “Performance”. When selecting the articles, the dates of publication and the number of citations were taken into account. No additional filters were applied to the search. After applying the search criteria 5,800 articles were found. From among them, a few articles have been selected that best established the importance of nutrition in athletes.

Results

148 responses to the questionnaire were obtained, of which 1 was rejected due to doubts to the accuracy of the received data. The average age of the respondents was 21.27 years of age. The oldest participant was 32,

the youngest – 15 years old. The vast majority (85%) of the respondents were aged between 17 and 23 years. 56% of the respondents were women, 44% – men. The average height of the male respondent was 1.819 m, female – 1.682 m. The height range was 1.62 m – 1.94 m and 1.55 m – 1.80 m respectively. The average BMI (body mass index) of the male respondent was 22.95, female – 20.96. The highest BMI value in male participants was 31.63, whereas in female participants – 26.73. The lowest BMI values were 17.18 and 14.36 respectively.

Over 56% of the respondents have practiced sports for more than 5 years, and over 86% – for more than a year (Figure 1).

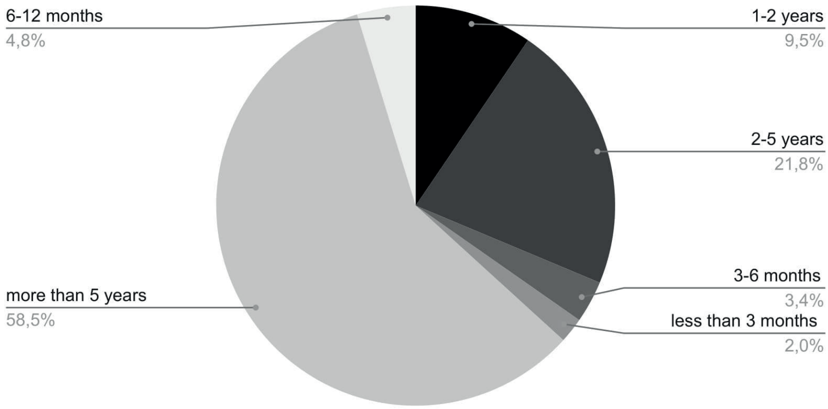


Figure 1. How long have you been practising sport?

Endurance, strength and mixed sports were represented by similarly large groups. The respondents declared the duration of the average training session ranging from <15 minutes to >90 minutes (Figure 2). Similarly differentiated responses were observed in the number of training sessions per week (mostly 2 to 5 times a week).

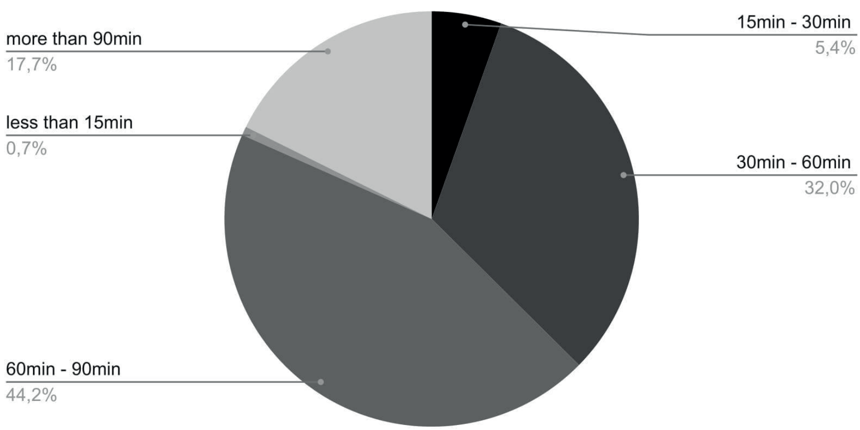


Figure 2. How long does the average training session last?

Almost 38% of people declared that they modify their diet due to training. It is worth mentioning that more than half of them were men, despite the fact that more women participated in the survey. Half of these people reported that their daily diet was modified depending on whether it is a training day. The most common diet modification on training days (81.5%) was the pre-workout meal, another strategy was to eat meals with increased protein or carbohydrate content on training days (17.5%). 48% of the additional meals consisted of: protein and carbohydrates (protein supplement with milk, lentils, chickpeas, beans, peas, broad beans); 30% – carbohydrates and sugar (sweets, fruit, corn bread, rice, flour dishes, potatoes); 22% – protein (e.g. protein supplement with water, seitan, poultry, pork) (Figure 3).

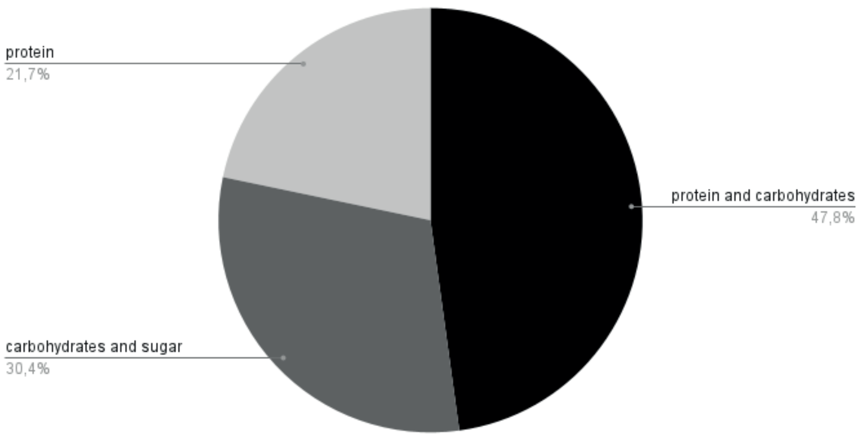


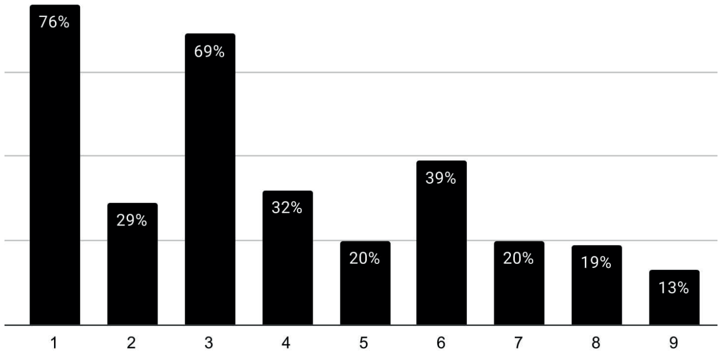
Figure 3. What does an extra meal consist of?

Most (79%) of the representatives of the second half who paid attention to the nutrition aspect of training reported that their nutritional strategy involves eating a meal in the pre-training period (I try to eat 1–2 hours before training – 39.3%/I try to eat immediately before training – 32.1%/I try to eat 1–2 hours after training – 17.9%).

Diet-modifying respondents who reported that their nutrition differed due to whether it is training day or not, were asked about the total caloric content of the meals of the day. The average energy value of meals on training days was 2,777 kcal, and on the remaining days – 2,322 kcal. Those who denied dietary diversification were asked about the caloric content and the amount of protein consumed on an average day. The average amount of protein consumed during the day was 87.5 g, which, with the average weight of the subjects being 67.5 kg, gives an average of 1.3 g of protein/kg/day. The 1.4–2.0 g/kg/day range of protein consumption proposed by the ISSN (Kerksick et al., 2017) was obtained by 32% of results, 61% was below 1.4 g/kg/day and 7% was above 2.0 g/kg/day. The average energy value of the meals was 2,400 kcal/day.

Among the respondents who do not modify their diet, the majority (59%) reported that they noticed certain trends related to nutrition in correlation with training. 72% of them related to eating a meal up to an hour before or after training.

82% of the diet non-modifiers asked if they had heard of any training-related nutritional strategies answered that they did. Their answers are presented in the graph (Figure 4).



1 – You should eat a certain amount of protein each day; 2 – You should eat a certain amount of protein on training days; 3 – You should consume a certain amount of kcal each day; 4 – You should consume a certain amount of kcal on training days; 5 – You should consume a certain amount of protein before training; 6 – You should consume a certain amount of protein after training; 7 – You should consume a certain amount of kcal before training; 8 – You should consume a certain amount of kcal after training; 9 – other.

Figure 4. What nutritional strategies have you heard about?

Discussion

The importance of diet in the context of training is very well researched and documented. For example, the scientists, who researched the influence of body composition on the risk of injury in ice hockey concluded from the obtained data that higher BMI of athletes correlates with increased risk (Grant et al., 2015).

There is no doubt that BMI depends on diet as numerous studies show. For instance, Kim et al. (2020) conducted a study that proves the impact of time-restricted diet on BMI. On the other hand, Klempel, Kroager, Varady (2013) studied changes in body mass and composition of participants, who were receiving alternate day fasting with a high-fat or low-fat diet.

A group of scientists studying baseball players found that dietary educational intervention resulted in some changes in the diet of athletes and an improvement in their performance (Rossi et al., 2017). Similar conclusions were drawn by the researchers of volleyball players (Wenzel et al., 2012), Brazilian volleyball players (Daniel et al., 2016), and young people practicing sports (Kavouras et al., 2012).

After analyzing many nutritional strategies, it was checked to what extent the respondents adhered to the two most thoroughly studied ISSN recommendations.

1. ISSN: "The peri-workout protein intake is a pragmatic and sane strategy for athletes, especially those who engage in large volumes of exercise. Not consuming protein after training (e.g. waiting a few hours after training) has no benefit " (Kerksick et al., 2017).

   Recommendation verification:

   The above recommendation is based on numerous studies on people practicing both endurance and strength sports. Ivy, Res, Sprague, Widzer (2012) conducted a study on trained cyclists which involved completing a 3-hour training session. The control group received a carbohydrate solution, and the test group received the same protein-enriched solution. The endurance turned out to be significantly increased in the study group. Saunders et al. (2004, 2007 respectively) conducted a similar study and obtained similar results. McLellan, Pasiakos, Lieberman (2014) studied the effect of protein intake immediately after training on the results on the next day. In this study the results favored athletes taking protein in the peri-training period too. Baty et al. (2007) concluded that the athletes consuming protein in the peri-training period had significantly reduced markers of muscle damage and a better hormone balance compared to athletes consuming carbohydrates alone. Tipton et al. (2001) stated that the response of muscle protein synthesis to consumption of an essential amino acid-carbohydrate solution immediately before resistance exercise is greater than that when the solution is consumed after exercise.

There were also studies, which did not conclude that the peri-workout meal resulted in any positive effect on training, but neither did they conclude that waiting a few hours had benefits. White et al. (2008) conducted a study on twenty seven untrained men. Subjects were randomly assigned to a pre exercise (received carbohydrate/protein drink before exercise and placebo after), a post exercise (received placebo before exercise and carbohydrate/protein drink after) or a control group (received placebo before and after exercise). Subjects performed eccentric quadriceps contractions on an isokinetic dynamometer. Eccentric exercise caused significant muscle damage, loss of strength, and soreness; however timing of ingestion of carbohydrate/protein supplement had no effect.

Questionnaire:

Among the respondents who modify their diet, the dominant strategy was to eat an additional meal containing protein in the peri-workout period (81.5 × 70.0 = 57.0%). However, this group consisted of only 19% of all respondents. Among the next 19% of respondents, the recommendation is practiced by 79% of them. Some people who do not intentionally modify their diet noticed that they unknowingly follow the above recommendation, while 39% of them heard of the recommendation. Overall, 52% of respondents consume a protein-containing meal per training session. It is worth mentioning that a large part (26%) of young athletes do it unawarely and that only 39% of respondents have heard of the above recommendation.

2. ISSN: "As with carbohydrates, timing considerations for protein appear to be of lower priority than optimal amounts of daily protein (1.4–2.0 g/kg/day)" (Kerksick et al., 2017).

   Recommendation verification:

   Tipton et al. (2007) compared the production of muscle proteins (MPS) between groups of athletes receiving protein before and after training. Scientists found no differences in MPS between the groups. On the other hand, Andersen et al. (2005) went a step further and proved that adding protein to meals resulted in an increase in the size of muscle fibers. Hoffman et al. (2009) administered protein to athletes at different time points in regard to training and did not notice significant differences in strength or muscle gain between the study groups. Aragon, Schoenfeld (2013) and Schoenfeld, Aragon, Krieger (2013) also investigated the effects of protein timing, and their conclusions were in line with the ISSN recommendation.

   Questionnaire:

   Among people who do not intentionally modify their diet, the majority had heard of the following strategy: "You should eat a certain amount of protein every day" (76%). Only the group of people who stated that they modify their diet to optimize training, and at the same time do not alter their diet due to whether it is a training day, were asked directly about the amount of protein consumed during the day. In this group, the average consumption of this macronutrient was 1.3 g/kg/day. 32% of the respondents fell within the recommended range. Others, who intentionally modified their diet, reported that their average energy value of the meals consumed was 455 kcal higher on training days. Considering that a) according to the survey, the dominant nutritional strategy in this group was to eat an additional meal containing protein, b) the most commonly known strategies were those related to the consumption of protein c) this group was the most sporty experienced group (61.5% have been practicing sports for more than 5 years), we assume that at least 80% of their representatives follow the above recommendation. In conclusion, many athletes have heard of the above recommendation, but not more than 50% of those with the greatest dietary awareness follow the above recommendation. We estimate that for all of our respondents the percentage of applicants would be around 30%.

Conclusions

1. Young men from Wrocław practicing sports choose their diet for training with more awareness in relation to young women from Wrocław (47% vs 29%).

2. Only 38% of young athletes from Wrocław pay attention to their diet. Considering how important in order to improve sports performance proper nutrition is, it was concluded that this percentage is too small.

3. 81.5% of respondents had heard of some nutritional strategies optimizing progress in training. Taking into account the number of different strategies they had heard of, it was concluded that the fact that only 38% pay attention to their diet, might be caused by too much information from too many sources. Such information overload might be difficult to verify. Improvements could be made by putting more emphasis on nutrition by coaches in clubs or physical education teachers in schools.

4. Despite the awareness of the recommendations, a relatively small group of young athletes from Wrocław follow the ISSN recommendations (52% to the first recommendation and 30% to the second recommendation).

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SPORTS AND EXERCISE MEDICINE IN INDIA: LOOKING BEYOND INJURY

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Abstract Sports Medicine (SM) is a new specialty in India which has been often projected as dealing only with treating musculoskeletal (MSK) sports injuries. With adequate training in medical-clinical and interventional physiological sciences, SM physicians have an important role to play as an essential part of the multidisciplinary and multispecialty team in the fight against the rise of physical inactivity, sedentary lifestyle and non-communicable diseases. Dope-free sports performance enhancement is another important aspect, which needs beyond the MSK centric approach of sports medicine. There is need for awareness and overall development of this unique specialty, with contribution from government side and non-government organizations.

Key words sports medicine, exercise medicine, physical inactivity, doping, sports performance

Introduction

Sports Medicine (SM) is a relatively new medical specialty in India, which started officially in 1986–1987 with PGDSM (post-graduate diploma in sports medicine) course at NSNIS Patiala (Netaji Subhas National Institute of Sports) Patiala, followed by MD sports medicine from 2010 onwards at various medical colleges. This specialty, which also is known by the name, Sports and Exercise Medicine (SEM), deals not only with the comprehensive medical care of elite and exercising individuals, but also with the use of exercise for medical and therapeutic purpose, and for health and fitness promotion. Hence, a myopic and only sports-injury-treatment centric approach of sports medicine is outdated one.

Sports Medicine against Non-Communicable Diseases (NCDs)

This specialty with its mother branch, Exercise Physiology or Medical-Clinical and Interventional Physiology (MCIP), has an important role for the fight against physical inactivity, sedentary lifestyle and non-communicable diseases (NCDs). Physical inactivity has been considered a global problem, a pandemic itself (Haseler, Haseler, 2022), and also the 21st century's biggest health problem in 2009 (Blair, 2009). Even though low level of physical activity (PA) is not the only leading health problem, but it is one of the most significant risk factors for NCDs (Forberger, Wichmann, Comito, 2022) and premature death, as reported in 2009 (Blair, 2009). Inactivity-induced low cardio-respiratory fitness (CRF), obesity and other adverse health effects are also significant causes of increased morbidity and NCDs (Blair, Sallis, Hutber, Archer, 2012; World Health Organization, 2010, 2013). In fact, low CRF is the most important NCD risk factor, more important than even the combined risks of smoking, obesity and diabetes (Blair, 2009; Tew, Copeland, Till, 2012). Low CRF has been reported to associate with all-cause mortality, incidence of and mortality due to cancer, cardio-vasculo-respiratory diseases in a dose-response manner (Steell et al., 2019). The mortality rate resulting from NCDs is expected to rise from 65% of all deaths in 2010 to >75% by 2030 (Blair et al., 2012). Apart from human suffering, NCDs cause significant economic loss of the family, community and the country (Blair et al., 2012). About 31.1% (27.9% men, 33.9% women) adults (≥15years) and 80.3% adolescent (13–15 years) as reported in 2012 (Hallal, Andersen, Bull, Guthold, Haskell, Ekelund, 2012), and 23% adults and 81.0% (77.6% boys, 84.7% girls) adolescents (11–17 years) as reported by World Health Organization (WHO) in 2010 (Guthold, Stevens, Riley, Bull, 2019; World Health Organization, 2013, 2018) are physically inactive worldwide. India ranks 5th among South-East Asian countries and above 12 countries worldwide with 15.6% (12.7% men, 18.4% women) physically inactive adults (≥15years) (Hallal et al., 2012), and 73.9% (71.8% boys, 76.3% girls) physically inactive adolescents (11–16 years) (Guthold et al., 2019). India has >20.77% (>135 millions) of the world's obese adults, and has a high central obesity prevalence rate of 16.9–36.3% (Ahirwar, Mondal, 2019).

There is rapid rise of diabetes (diabesity), hypertension and other obesity-related NCDs among South Asian countries (Misra, Khurana, 2011). India is often considered as the "diabetes capital", having 16.63% (77millions) of the total individuals with diabetes in the world in 2019, and it is expected to rise to 17.46%, with an increment of 31.17% individuals with diabetes in India by 2030 (Federation, 2019). One study reported 42.1% prevalence for metabolic syndrome among elderly (≥60 years) southern Indians (Sinha, Bhattacharya, Deshmukh, Panja, Yasmin, Arlappa, 2016). India also has very high hypertension prevalence rate of 30.7% (234 million) among adults (equal to or more than 18 years) with >2 times the prevalence (22.4% vs 10.5%) of that of United States (US) among young adults (20–44 years) (Ramakrishnan et al., 2019). India was projected to have more individuals with cardiovascular diseases (CVDs) than any other region of the world by 2020 (Murray, Lopez, 1996). Of concern, the South Asians including Indians have the early onset and higher risk of NCDs even at relatively lower obesity indices (Misra, Khurana, 2011), and Indians also experience mortality due to cardiovascular events (CVEs) almost a decade earlier than developed countries with 52% CVE-related morality for <70 years Indians as compared to 23% in those countries (Ramakrishnan et al., 2019).

Realising the need for urgent action, many international organizations have come forward with various programs to fight physical inactivity and sedentary behaviour. "WHO Global Strategy on Diet, Physical Activity and Health, 2004", "Toronto Charter for Physical Activity: A Global Call for Action, 2010", "Exercise is Medicine" by American College of Sports Medicine are few examples (Blair et al., 2012). WHO member states aimed in 2011 to halt rise of diabetes and obesity, and 25% reduction of hypertension prevalence by 2025 and 10% reduction of physical inactivity by 2025 with "25 by 25" goal (World Health Organization, 2013), and 15% by 2030 under "Global Action Plan on Physical Activity 2018–2030" (Carrard et al., 2019; World Health Organization, 2018). United Nations (UN) member states aimed to reduce premature mortality from NCDs by one-third by 2030 (United Nations Population Division, 2015). Government of India (GOI) launched "Fit India" movement, among others, to take the nation towards fitness and wellness, and make it healthier on 29th August 2019, the national sports day of India, celebrated in the honour of the hockey "wizard" or "magician", Major Dhyan Chand who was born on 29th August 1905 (Fit India, 2019; International Olympic Committee, 2019a).

WHO, with the support of GOI, is establishing the WHO Global Centre for Traditional Medicine (GCTM) in Gujarat, India (World Health Organization, 2022). Various lifestyle interventions in the form of Yoga, dietary changes and exercise form an integral part of Indian traditional medicine system including ayurvedic medicine. In fact, the origin of exercise-is-medicine has been proposed by some to be from Indian Indus Valley and Chinese Yellow River civilisations (Sharma, 2022). SEM physicians, with adequate training in MCIP or Interventional Clinical Physiology (ICP) in the form of diet/nutrition, exercise, sleep and other lifestyle and functional interventions, can work in an integrated and holistic manner with traditional medicine practitioners to tackle the pandemic of physical inactivity, obesity and NCDs (Sharma, 2022). This is especially important since traditional medicine is used by about 80% of the world's population, and is also the first line of treatment for many diseases (World Health Organization, 2022).

Adequate training in sports medicine, exercise medicine and clinical-interventional exercise physiology is absolutely essential, which will help in identification and correction of various lifestyle abnormalities using physiological approach before pharmacotherapy or surgical intervention. Being physically active is not enough but one has to reduce the amount of being sedentary too. Those who are physically active but spend too much time in prolonged sedentary behaviour like uninterrupted sitting, are still at high risk, which is the so called "active couch potato" phenomenon (Owen, Healy, Matthews, Dunstan, 2010). The physiological effects due to prolonged sedentary time (inactivity physiology) is not same as that of too little PA. The adverse health effects of prolonged sitting time are independent of the protective effect of regular PA (Owen et al., 2010). A physician, with deep understanding of both exercise physiology and sedentary physiology, can therefore help in fight against physical inactivity and sedentary behaviour effectively. Hence, recruitment, engagement and attachment of trained physicians should be done in all national and state programs related with health, PA, exercise, fitness, lifestyle change and NCDs etc; and in appropriate organizations, bodies or institutions or departments including government health service and public hospitals. They should not be restricted to only sports and military sectors (Sirisena, Lim, Teh, 2016).

Sports Medicine for Dope-Free Performance

Increasing doping with use of banned substances/methods among athletes is unfortunately not uncommon. Even, in some countries, in the past, there were reports of medically-supervised and controlled use of performance enhancing drugs or methods, and also state-sponsored doping. This is because performance comes as the first priority above healing and health for most elite athletes (Hoberman, 2002; Speed, Jaques, 2011; Wiesing, 2011). World Anti-Doping Agency (WADA) was formed in 1999, which revises WADA code regularly. The code contains banned substances and practices (Speed, 2013; World Anti-Doping Agency, 2019b).

The global percentage of analytic anti-doping rule violations (A-ADRVs), which is the violation of WADA code article 2.1 dealing with athletes, out of total adverse analytical findings (AAFs) decreased from 66.42% in 2013 to 43.73% in 2016. AAFs in athletes with valid therapeutic use exemptions (TUEs) increased from 8.78% in 2013 to 11.18% in 2016 (World Anti-Doping Agency, 2019a). However, the percentage of non-analytical ADRVs (NA-ADRVs), which is the violation related to WADA code article 2.2 to 2.8 (2009 WADA code) and 2.10 (2015 WADA code) and applies to medical staff and other athlete support personnel (ASP) apart from the athletes, out of total ADRVs increased from 13.62% in 2013 to 16.87% in 2016 with 7.81% NA-ADRVs by ASPs in 2016 (World Anti-Doping Agency, 2019a).

The situation for India is quite worrisome which needs urgent and effective action from all sides. The percentage of ADRVs (A-ADRVs, NA-ADRVs) out of global ADRVs for India was 4.86 (5.39, 1.50)% in 2013, 5.67 (6.29, 1.73)% in 2014, 6.07 (6.97, 0.71)% in 2015 and 4.33 (5.13, 0.37)% in 2016 (World Anti-Doping Agency, 2019a). In fact, India has been consistently on the top as the country with most ADRVs in Asia from 2013 to 2016; and in the world as 4th in

2013, 3rd in 2014 and 2015, and fortunately dropped to 6th in 2016 with a total of 69 ADVRs (68 A-ADVRs, and 1 NA-ADVR in wrestling). Maximum ADRVs were in athletics (30.43%) followed by powerlifting and weightlifting (20.29% each), kabaddi (13.04%) and wrestling (7.25%) (World Anti-Doping Agency, 2019a). National Anti-Doping Agency (NADA) of India, which is affiliated to WADA and was established on 24th November 2005 by GOI with a mission of dope free sports in India, reported a total of 187 (4.30% of total sample analysed) AAFs and 18 (0.41% of total sample analysed) TUEs from April 2018 to March 2019. Maximum AAFs were in bodybuilding (32.09%), followed by weightlifting (21.93%), athletics (9.63%), powerlifting (6.95%), wrestling (3.21%), and kabaddi and Judo (2.67% each) (National Anti Doping Agency, 2017, 2018).

Although NADA has conducted many anti-doping awareness programmes in the country, active involvement of SEM physicians by the concerned authority is unfortunately lacking (National Anti Doping Agency, 2017). SEM physicians are specially trained in anti-doping science and most knowledgeable among ASPs (Mazanov, Backhouse, Connor, Hemphill, Quirk, 2014). SEM physicians should be in the front line for the fight against doping menace and have major and lead role in anti-doping education and awareness campaign. This is also important as the extent of “accidental” doping seems to be high, which can be approximated from the WADA statistics of 4.17%, 13.66% and 8.78% in 2013; 5.77%, 13.86% and 9.79% in 2014; 7.69%, 7.06% and 11.90% in 2015 for “no sanction”, cases with valid reason without TUE, and those with valid TUEs respectively (Chan, Tang, Yung, Gucciardi, Hagger, 2019). Recruitment, attachment and engagement of SEM physicians should be done in all appropriate programmes, organizations, bodies, institutions or universities which deal with anti-doping, sports, performance and physical education etc including sports federations, and national and state government youth affairs and sports departments.

Apart from fighting doping, the relatively poor international sporting-performance to population ratio needs urgent focus. The sports medicine component of SEM and performance-related sports and exercise physiology (pSEP) are particularly important in context of India. India is the second populous country at 1.21 billion (Office of the Registrar General & Census Commissioner, 2019), out of which 65% are under 35 years and 27.5% between 15–29 years, making it also one of the most youngest nations (Department of Sports, 2018). Unfortunately, Indian performance at international sports, specially summer Olympics is not so good. From Paris 1900 to Rio 2016 summer Olympic games, Indian had won only 9 gold, 7 silver and 12 bronze medals, out of which only one sports discipline, men’s hockey, is credited for 8 gold, 1 silver and 2 bronze medals (Indian Olympic Association, 2018; International Olympic Committee, 2019b). In the last summer Olympics in Rio 2016, India sent its 117 athletes contingent which was the largest up to now but managed to pick two medals (1 silver and 1 bronze) (Indian Olympic Association, 2018; International Olympic Committee, 2019b). Relative to its huge population, the amount of money India spent on sports is meagre, and was Rs.1393.21 crores or about 3.196 paise per person per day for 2017–2018, which has fortunately been increased to some extent now (Parliament of India Rajya Sabha Department-Related Parliamentary Standing Committee on Human Resource Development, 2018). Another major concern which has been repeatedly raised is the non-presentation of sportspersons in, and heading and managing of sports institutes, including Sports Authority of India (SAI), by persons without any sports background and in a strict unwieldy and monolithic bureaucratic manner (Parliament of India Rajya Sabha Department-Related Parliamentary Standing Committee on Human Resource Development, 2015).

After the dismal performance at Rio 2016, the GOI is actively working from the grassroots to elite levels, specially under the national programme, “Khelo India”, for the promotion and development of sports, creating sporting culture and hence improving the country’s international sporting performance (Department of Sports, 2018;

Parliament of India Rajya Sabha Department-Related Parliamentary Standing Committee on Human Resource Development, 2018). Target Olympic Podium Scheme (TOPS) was established in 2014 for providing assistance to top elite athletes who are potential medal winners in Olympic Games (Sports Authroity of India, 2019). A task force was also constituted for preparing action plan for the next three Olympic Games (2020, 2024 and 2028) in 2017 by GOI (Press Information Bureau, 2017). However the engagement of SEM physicians who are the specialists in this field is unfortunately lacking. This needs to be addressed for the long-term success. Also, there is inadequate number of SEM physicians in the country, who are well trained in pSEP, MCIP and sports and exercise sciences (SES).

GOI under the Scheme of Human Resource Development in Sports is focusing on the academic and intellectual aspect of sports development (Department of Sports, 2019). Central institutes/universities of national importance and excellence, based on the model of All India Institute of Medical Sciences (AIIMS), exclusively focusing on Sports-Exercise Medicine and Sciences (SEMS) and MCIP should be set-up throughout the country, so are national centres similar to the United Kingdom (UK) National Centre for Sport and Exercise Medicine (NCSEM) which was launched in 2012 in UK for delivering an Olympic health legacy (Tew et al., 2012). Recruitment of SEM physicians and scientists and development of world-class SEMS and MCIP departments should be there in National Sports University (NSU), the first central sports university in India which was set up in 2018 in Imphal, Manipur by the GOI for promoting sports education and functioning as the national training centre for selected sports disciplines (National Sports University, 2019). This is to uplift the nation to be among the world's sports superpowers, instead of running the university in a physical education centric manner only, similar to other already existing physical education institutes and universities in the country.

Sports Medicine towards Development & the Future

Recently, sports medicine specialty has been gaining popularity among medicos, SES community and general public. This is due to the effort from the government as well as from various non-governmental organizations (NGOs). There are three main national level non-governmental organizations (NGOs) working in the above area in India – Indian Association of Sports Medicine (IASM), Indian Federation of Sports Medicine (IFSM) and Indian Society of Sports and Exercise Medicine (ISSEM). IASM is a society of professionals from various fields of sports sciences which was established in 1971 (Indian Association of Sports Medicine, 2012), whereas IFSM was established in 2004 as a trust of doctors of modern medicine for sports (Indian Federation of Sports Medicine, 2013). ISSEM is a relatively young national society, formed and registered on 9th July 2019 by SEM specialists primarily for them, but was subsequently expanded to include all SEMS and MCIP professionals, acknowledging the multi- and inter-disciplinary nature of SEM (Indian Society of Sports and Exercise Medicine, 2020). With the increasing scientific and medical information and the huge magnitude of research available, these organisations are helping SEM physicians to keep updated or incorporate best evidences into the practice, and hence use of evidence-based SEM (EBSEM). Collective, collaborative and cooperative constant effort is needed among the organizations to establish SEM as a well-developed specialty, to popularise and make sure SEMS and MCIP are utilized to the fullest; to spearhead the EIM movement for the fight against physical inactivity and NCDs, making India fit and healthy; and to effectively convert the huge youth population and potential of India into sporting excellence by providing evidence-based scientific and medical inputs.

With advancement of medical field, personalized medicine and expectations of enhanced human and sports performance, SEM speciality is the need of the future. Advanced research in the field needs attention, which will surely prove fruitful in the future by leading to discoveries and inventions of newer and better methods of athletes selection, nutrition, care and training; ergonomic, supportive and protective devices related to physical activity and sports performance etc. Thus, SEM specialists who are active in research in this field, or who want to pursue research should be adequately recruited and funded. It is time to move beyond the myopic and outdated, musculoskeletal-injury-treatment-centric only model of sports medicine to a physiology-centric, human performance, sports performance, fitness and overall health based model. The general unfamiliarity of SEM and confusion of it with other traditional medical and allied health specialties like orthopaedics, physical medicine and rehabilitation (PMR) or physiotherapy/physical therapy is slowly disappearing, with emergence of SEM as a fully-fledged specialized medical field. This will ultimately serve as booster for enhanced human and sports performance, reduced injuries and disabilities related not only to sports and physical activities but also to sedentary lifestyle.

As the determinants of health, fitness and dope-free human and sports performance are multifactoral, there is need of multidisciplinary-multispecialty and holistic approach. Strengthening of SEMS and MCIP with SEM physicians working closely with other related & allied professionals is definitely going to make a major impact. The “integrated performance health management and coaching model” has been adopted recently which highlights the importance of integrated approach (Brukner et al., 2018). With promotion and wide spread access of SEM specialized services, sports performance of athletes in national and international competitions will also improve. Active engagement and recruitment of SEM specialists should therefore be done in both government and non-government sectors, and adequate research facilities and infrastructure should also be provided for the development of SEM.

Conclusion

Sports Medicine or SEM is not confined only to treating musculoskeletal injuries, but has a much larger role to play. It has potentially significant contribution in the fight against the rise of physical inactivity, sedentary lifestyle and NCDs, and also doping and low sports performance to population ratio. Awareness and development of this important and unique specialty is the need of the present, with its prominent role in the multidisciplinary and multispecialty team approach to the health, fitness and dope-free human and sports performance.

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EFFICACY OF EXERCISE PROTOCOLS ON BALANCE IN BADMINTON PLAYERS – A SYSTEMATIC REVIEW & META-ANALYSIS

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[A] Study Design; [B] Data Collection; [C] Statistical Analysis; [D] Manuscript Preparation

Abstract Objective. The goal of this "systematic review" and meta-analysis is to find out the efficacy of exercise regimes on balance in badminton players.
Study Design. Systematic review and meta-analysis.
Data Source. Pub Med, "Cochrane database (Cochrane Central Register of Controlled Trials)", Google Scholar, Springer, and DOAJ.
Eligibility criteria. Limits were applied to database searches to identify papers published in English and only human studies were included.
Results. Result of Meta – analysis was statistically significant in "anterior component of Y-balance test" (MD = 2.39, 95% CI = 1.90, 2.89; "$p \leq 0.00001$") with low heterogeneity ($I^2 = 0\%$, $p < 0.41$). There was statistically significant improvement in postero-medial component of y- balance (MD = 2.87, 95% CI = 0.55, 5.19; $p \leq 0.02$) with "moderate heterogeneity" ($I^2 = 39\%$, $p < 0.19$). Result showed statistically significant improvement in postero-lateral component of y- balance test (MD = 3.09, 95% CI = 0.64, 5.65; $p \leq 0.02$) with "moderate heterogeneity ($I^2 = 38\%$, $p < 0.20$)". There was "statistically significant "improvement in overall balance of y-balance test in "experimental group as compared to control group (MD = 8.49, 95% CI = 4.62,12.36; $p \leq 0.0001$) with low heterogeneity ($I^2 = 0\%$, $P < 0.47$)".
Conclusion. This systematic and meta-analysis concluded that various exercise protocols may result in improvement in the balance of badminton players.
PROSPERO registration number: CRD42020193620.

Key words badminton, core stability training, Pilates, Plyometric, Swiss ball, core strengthening, balance

Introduction

Exercise protocols like core stability training, Pilates, Plyometric, Swiss ball, PNF, Sensorimotor training, and core strengthening are frequently used by physiotherapists to treat trunk muscle imbalance, weakness, and lower limb injuries. "Muscular corset with abdominals in front, gluteal and erector spine at the back, diaphragms roof, hip girdle musculature and pelvic girdle as bottom describes the core." During activities where the motion of upper and lower extremities is involved such as jumping, throwing, and running, the spine and trunk are stabilized by the core muscles (Akuthota, Ferreiro, Moore, Fredericson, 2008). For improving performance, decreasing the risk of injuries in athletes (Sekendiz, Cug, Korkusuz, 2010) rehabilitation of patients with pain in lower back (Marshall, Murphy, .2006). and for enhancing physical fitness in healthy individuals (Sekendiz, 2010) core strength training has been used widely (Saeterbakken, Van den Tillaar, Seiler, 2011; Schilling, Murphy, Bonney, Thich, 2013; Stanton, Reaburn,

Humphries, 2004; Tse, McManus, Masters, 2005) and it is also believed that people with weak trunk extensor muscles have a risk of back pain (Lee, Hoshino, Nakamura, Kariya, Saita, Ito; 1999).

Pilates, which helps improve balance, posture, increase core strength, and peripheral mobility is believed to overall improve athletic performance, is a kind of exercise that incorporates in itself various series of stretching and strengthening exercises taking into account proper trunk control and breathing. It is believed to act upon trunk stability principles which are also called core stability (Akuthota, Nadler, 2004; Niehues, 2015). For improving athletic performance, Pilates may be helpful in improving posture, balance, increasing core strength and peripheral mobility (Anderson, Spector, 2000). The main objective of this exercise is supposed to be organizing the mind, body, and breath which in turn helps to build up abdominal muscles that are sleek and strong and also helps to build a strong and agile back (Tarpey, 2005).

Another type of exercise is plyometric which is believed as an effective training modality that helps in improving awareness about joint, balance, and neuromuscular properties (Arazi, Asadi, 2011). It involves stretching exercises which involve musculotendinous tissue shortening cycle that brings about maximum power production by using "the energy stored during eccentric phase and muscle spindle stimulation" which is needed for reactive neuromuscular training that is a concentric phase of movement (Asadi, de Villarreal, Arazi 2015).

Neural adaptations, that enhance proprioception, kinesthesia, and muscle performance characteristics, may be facilitated by plyometric training (Patel, 2014). "Repeated stimulation of mechanoreceptors that are near the end range of motion creates these adaptations". Plyometric training and balance relationship are attributed to neuromuscular adaptability development (Arazi, 2012).

Almost Identical to bodyweight exercises are the Swiss ball exercise, although Swiss ball exercises are slightly difficult. The strength and stability of stabilizing muscles can be improved by an unstable surface of a Swiss ball (Woodward, 2013).

"Badminton is one of the world's most popular racquet sports", attracting both recreational and competitive players. "Jumps, lunges, quick changes of direction, rapid arm movements, rapid eye-hand coordination", and a good awareness of body position are all required in badminton (Shariff, George, Ramlan; 2009; Wang, Moffit, 2009). Of all sports injury's badminton (a non-contact sport) constitutes a total of 1–5% injuries (Fahlström, Björnstig, Lorentzon, 1998; Høy, Lindblad, Terkelsen, Helleland, 1994; Krøner, Schmidt, Nielsen, Yde, Jakobsen, Møller-Madsen, Jensen 1990).

In badminton, significant physical requirements are motor and action controls, "reaction time, foot striding, and static and dynamic balance" (Phomsoupha, Laffaye, 2015; Laffaye, Phomsoupha, Dor, 2015). A high level of dynamic balance and strength are essential for badminton players when moving around the court (Phomsoupha, Laffaye, 2015). Badminton is a dynamic equilibrium sport that entails losing "balance in the air and then regaining it after landing". As a result, players require dynamic balance and body coordination (Kong, Liu, 2013). Balance interventions like Pilates, core stability training, and Swiss ball training can improve performance in badminton players. When a player forces the wrist upward to touch the "shuttlecock with the racket frame", the trunk rotates internally, emphasizing the need for core stability exercises in improving this movement pattern and maintaining balance in badminton players (Chen, Zhang, Gao, 2014). In young badminton players, eight weeks of core stability training improved their capacity to maintain optimal lower limb dynamic balance and improved their smash stroke performance (Hassan, 2017).

In overhead athletic pursuits such as badminton smashing, "core musculature serves as a connecting link between the upper and lower limbs" (Laffaye et al., 2015; Fröhlich, Felder, Reuter, 2014). Many factors contribute to producing high performance or increasing balance of badminton players such as upper limb strength, lower limb strength, and core strength.

The existing research literature regarding the effect of exercise protocols on balance in badminton players is still ambiguous. Studies corroborate (Hassan, 2017; Alikhani, Shahrjerdi, Golpaigany, Kazemi, 2019; Kalra, Yadav, Pawaria, 2019; Ozmen, Aydogmus, 2016; Amirkolaei, Balouchy, Sheikhhoseini, 2019; Sighamoney, Kad, Yeole, 2018; Srivastav, Nayak, Nair, Sherpa, Dsouza, 2016; Watson et al., 2017; Sandrey, Mitzel, 2013). as well as contradict (Arazi, 2012; Sato, Mokha, M. 2009) the effect of exercise protocols on balance in badminton players. The generalizability is limited because of various methodological loopholes like research has a limited sample size.

To our knowledge, there hasn't been any "systematic review or meta-analysis" on the impact of exercise protocols on badminton players so far. Therefore, the aim of the present "systematic review is to evaluate the efficacy of various exercise protocols on balance in badminton players".

Methods

Eligibility criteria

A randomized controlled trial performed to find out the efficacy of exercise protocols on "balance in badminton players" were included.

Limits were applied to database searches to identify papers published in English and only human studies were included.

Exclusion criteria

Reviews, case reports, editorials, letters, erratum, comments studies were excluded from the study.

Search strategy: "Preferred Reporting Items for Systematic Reviews" and "Meta-analysis were used to conduct the systematic review and meta-analysis (PRISMA guidelines 2015)". This "systematic review and Meta-analysis" are registered in the "International Prospective Register of Systemic Reviews (PROSPERO) with identification number" CRD42020193620.

To identify significant studies, five databases Pub Med, "Cochrane database (Cochrane Central Register of Controlled Trials)", Google Scholar, Springer and DOAJ were searched from inception to June 2020. The search strategy used for Pub Med is given in supplementary material 'A'.

Medical Subject Heading (Mesh) terms and associated keywords were incorporated in the search process according to the "Participant Intervention Comparison Outcome (PICO) strategy", which was then integrated with the "Boolean operators" ("AND" & "OR") utilizing the 'Advance' and "Expert search" choices. In order to conduct the search, title and abstract were used.

Selection criteria

To remove the duplicate records of the electronic database, Mendeley was used.

Two authors (NKI &MM) independently assessed the title/abstract of the identifying records. The full text of relevant papers was collected to assess them against the selection criteria.

Any disagreement among the authors was resolved by discussion and consensus. If the entire text of a relevant study was not available online, first or corresponding authors were contacted. In addition to this, the reference list of qualified publications was evaluated manually to detect the studies of interest.

Data extraction and quality assessment

The data was retrieved by two investigators working independently (NKI and MM). Data extracted from the study were investigator and year, study design, the number of participants, sample size, trial duration, study location, trial type, intervention, outcome measures, and results. The primary outcome was a mean change in balance to evaluate the efficacy of the treatment. Missing data of standard deviation for change from baseline was imputed using a correlation coefficient. On other hand, to record any adverse effect safety outcome was measured. The "Chi (X^2) and I^2 –statistics (degree of heterogeneity)" were employed to assess study heterogeneity". The "heterogeneity of the studies was assessed using the I^2 scale, with 0–25" percent indicating "low heterogeneity", 26–75 percent suggesting "moderate heterogeneity," and 76–100 percent indicating "severe heterogeneity." The meta-analysis was carried out using Review Manager Software (Rev Man, version 5.4). Every study's methodological quality was appraised using the Pedro rating system. The "internal quality and validity of the randomized control trials" were assessed using the Pedro rating scale. It is an 11-point scale, "a score of 6–10 indicates excellent quality, a score of 4–5 indicates acceptable quality, and a score of 3 indicates poor quality". Cochrane collaboration risk of bias tool evaluated the risk of bias. The tool consisted of 7 "primary sources for bias: Random Sequence Generation, Allocation Concealment, Selective Reporting, blinding of participants and personnel, Blinding of outcome assessment, incomplete outcome data and other sources of bias". Authors used independent sources to categorize bias risk as high, low, or unclear.

Mean differences including standard deviation (SDs) for change in anterior, posteromedial, Posterolateral, and overall balance (MSEBS) scores were used to analyze the "efficacy of exercise protocols on balance". Confidence interval (CI) was used to assess continuous variables with 95% (CI) along with weighted mean differences (WMD). At p0.05, the Results of the "meta-analysis" were deemed statistically significant a $p \geq 0$. The "Review Manager (Rev Man, version 5.4) software" was used to generate forest plots and funnel plots.

Results

Study selection

"A total of 105 articles were retrieved from the database searches, of which 5 met the selection criteria. 3 out of 5 studies comprising 40 players in the experimental group and 40 players in the control group were included for the Meta-analysis of the anterior component of the Y-balance test. 3 out of 5 studies comprising 40 players in the experimental group and 40 players in the control group were included in the Meta-analysis of the posteromedial component of the Y-balance test. 3 out of 5 studies comprising 40 players in the experimental group and 40 players in the control group were included for the Meta-analysis of the Posterolateral component of Y the balance test. 2 out of 5 studies comprising of 28 players in the experimental group and 23 players in the control group were included in the Meta-analysis" of overall components of Y-balance test.

Study characteristics

The characteristics of the included studies are represented in Table 1. Most studies were conducted in Iran (2) (Alikhani et.al., 2019; Amirkolaei et.al., 2019). Egypt (1) Hassan (2017), India (1) Kalra et al. (2019), and Turkey (1) Ozmen, Aydogmus (2016). Only Randomized control trials were included.

All included studies provided dynamic balance training to the badminton players by core stability training, core strengthening exercise, Pilates, Plyometric, and Swiss ball training methods.

Only one study took a stroke to smash velocity and accuracy in badminton players along with dynamic balance as outcome measures.

Table 1. Studies were included having major characteristics

Sr. No.	Author (year)	Sample size	Age, group, and Intervention	Outcome measures	Conclusion
1.	Hamed et al., 2017	20	Under 19 ages 1. Experimental group (n = 10) = = CST 8 × 2 (25 min.) weeks 2. Control group (n = 10) = badminton traditional training	Smash velocity, Accuracy, Balance	After "eight week of core stability training, lower limb dynamic balance and smash stroke performance increased"
2.	Preeti et al., 2019	40	Age group 17–28 years 1. Experimental group (n = 20) Pilates + Conventional Training 5 × 2 (60 min.) weeks 2. Control group (n = 20) = Conventional training	Agility, Lower Limb Strength, Dynamic Balance, Co-ordination	Pilates exercise training improves balance, agility, lower limb strength, and coordination in badminton players
3.	Alikhani et al., 2019	22	Age group 15–25 years 1. Experimental group (n = 12) = Plyometric Training 6 × 3 (20 min.) weeks 2. Control group (n = 10) = Routine Exercise	Dynamic balance, Knee proprioception	According to a study, novice female badminton players improved their dynamic balance and knee proprioception after a six-week plyometric training programme
4.	Ozmen et al., 2016	20	Age group 10–12 years 1. Training group (n = 10) = Core stability training Regular scheduled training 6 × 2 weeks 2. Control group (n = 10) = Regular scheduled training	Core Endurance, Dynamic balance, Agility	Core dynamic & dynamic balance is improved by 6 weeks of CST but agility in adolescent badminton players is not improved
5.	Amirkolaei et al., 2019	29	Age group 11–16 years 1. Experimental group (n = 16) = Swiss ball training 8 × 3 weeks 2. Control group (n = 13) = Conventional training	FMS Test, Balance test (upper & lower limbs)	Eight weeks of Swiss ball exercise enhance the consistency of functional motions and the balance of the upper and lower limbs in teenage badminton players

Assessment of quality

The quality of the studies included is represented in Table 2.

All of the included studies' research scored highly on the "Pedro scale". Three out of five studies scored (six) (Hassan, 2017; Alikhani et.al., 2019; Kalra et.al., 2019). Two studies scored (five) (Ozmen, Aydogmus, 2016; Amirkolaei et.al., 2019). All the studies were of good quality.

Table 2. Pedro Scoring scale was used for quality assessment

Art	1	2	3	4	5	6	7	8	9	10	11
Article	Specified eligibility Criteria	Random allocation	Concealed allocation	Similar baseline	Subjects blinding	Therapist's blinding	Assessors blinding	Measures of key outcomes from greater than 85% of the subject	Intention to treat analysis of one key outcome	Statistical comparisons between-group of at least one key outcome	Variability for at least one key outcome
Hamed et al., 2017	Y	Y	N	Y	N	N	N	Y	N	Y	Y"
Preeti et al., 2019	Y	Y	N	Y	N	N	N	Y	N	Y	Y"
Alikhani et al., 2019	Y	Y	N	Y	N	N	N	Y	N	Y	Y"
Ozmen et al., 2016	Y	Y	N	N	N	N	N	Y	N	Y	Y"
Amirkolaei et.al., 2019	Y	Y	N	N	N	N	N	N	N	Y	Y

Note: Y = YES, N = No.

Table 3. Cochrane Collaboration Risk of Bias Assessment

Study	Random sequence generation	Allocation concealment	Selective reporting	Other sources of bias	Participants and personnel	Outcome Assessment	Incomplete outcome data
Hamed et al., 2017	Low	Unclear	Low	Unclear	Unclear	Unclear	Low
Preeti et al., 2019	Low	Unclear	Low	Unclear	Unclear	Unclear	Unclear
Alikhani et al., 2019	High	Unclear	Low	Unclear	Unclear	Unclear	Unclear
Ozmen et al., 2016	Low	Unclear	Low	Unclear	Unclear	Unclear	Low
Amirkolaei et.al., 2019	Low	Unclear	Low	Unclear	Unclear	Unclear	Low"

"Risk of bias": The included studies' risk of bias is represented in Figure 2. "Random sequence generation was described adequately in 4 studies. (Hassan, 2017; Kalra et al., 2019; Ozmen, Aydogmus, 2016; Amirkolaei et al., 2019). Selecting reporting" was done in most of the studies (Hassan, 2017; Fröhlich et al., 2014; Kimura et al., 2014; Nesser et al., 2008; Richardson, Jull, Hides, Hodges, 1999; Alikhani et al., 2019 Kalra et.al., 2019; Ozmen, Aydogmus, 2016; Amirkolaei et al., 2019). Incomplete outcome data" were described in three studies. Hassan (2017), Ozmen, Aydogmus (2016), Amirkolaei et al., 2019). All of the studies included had a low overall risk of bias.

Meta-analysis: The anterior component of the Y-balance test was assessed by three studies included in the Meta-analysis. Exercise protocols improved balance in badminton players with statistically significant differences "($p \leq 0.00001$) and low heterogeneity ($I^2 = 0\%$, $p < 0.41$) (Figure 1)".

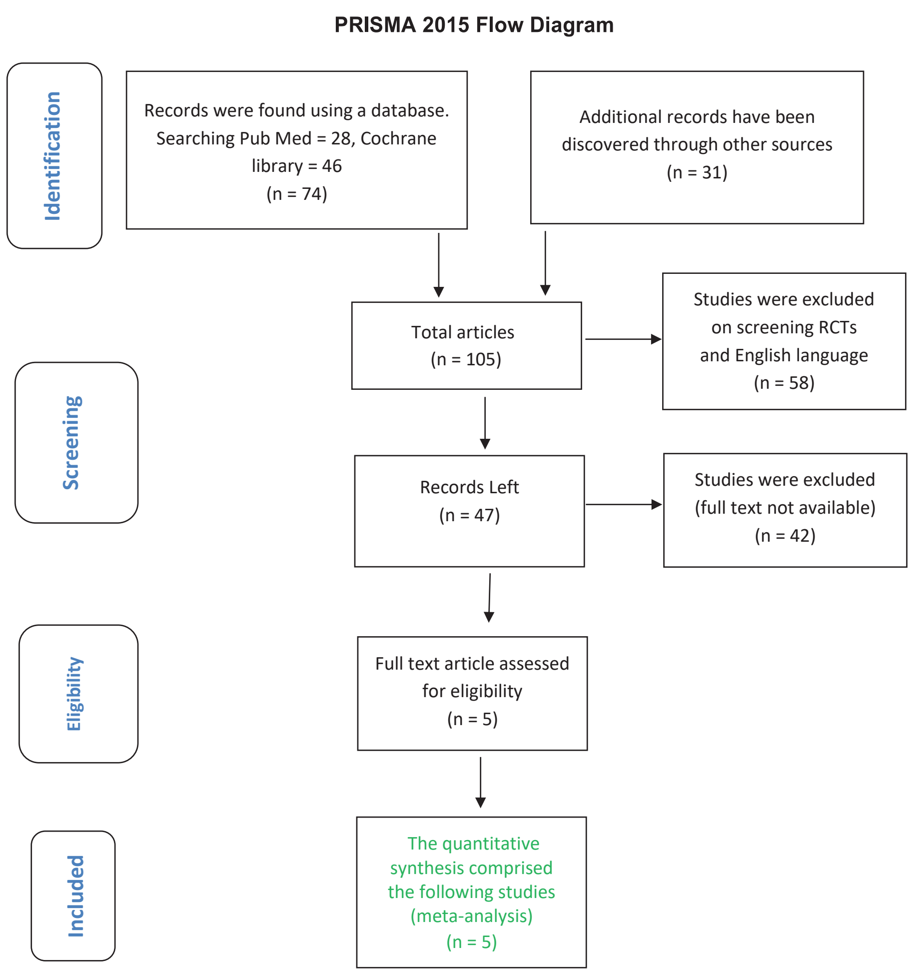
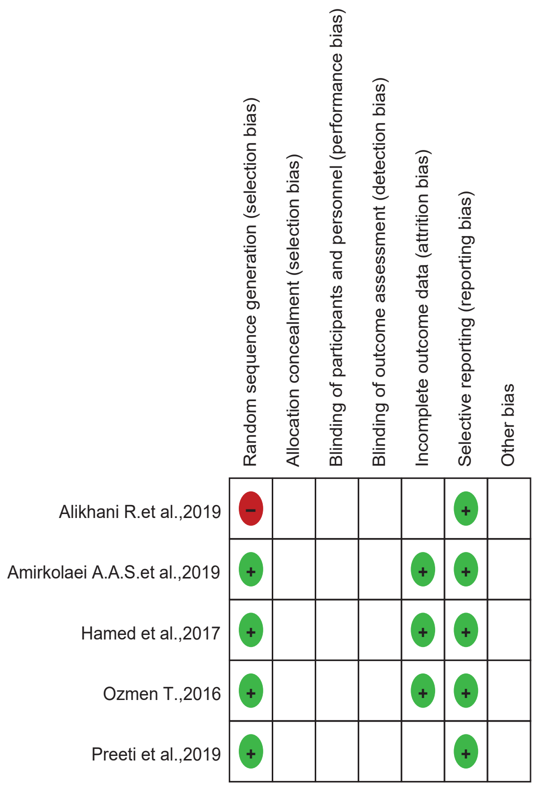


Figure 1. A flow diagram depicting a number of studies

A “meta-analysis of the posteromedial component of the Y-balance” test included three studies. The result of “meta-analysis was statistically significant ($p \leq 0.02$) with “moderate heterogeneity ($I^2 = 39\%$, $p < 0.19$)” (Figure 3)”.

Three “studies were included in the “Meta-analysis of the posterolateral component of the Y-balance test”. The result showed statistically significant improvement ($p \leq 0.02$) of balance in badminton players who underwent exercise protocols with “moderate heterogeneity ($I^2 = 36\%$, $p < 0.20$)” (Figure 5).

Two studies were included in the Meta-analysis of the overall balance of the Y-balance test. Results were “statistically significant ($p \leq 0.0001$)” with “low heterogeneity ($I^2 = 0\%$, $p < 0.47$)” (Figure 7).



Studies in green or positive are at low risk of bias. Studies in red or negative are at high risk of bias. Studies in blank are at unclear risk of bias.

Figure 2. Risk of bias summary

Study or Subgroup	Experimental Mean	Experimental SD	Experimental Total	Control Mean	Control SD	Control Total	Weight	Mean Difference IV, Random, 95% CI	Year
Ozmen T.,2016 (Anterior Component)	7.47	5.63	10	1.78	7.42	10	0.7%	5.69 [-0.08, 11.46]	2016
Hamed I.et al.,2017(Anterior Component)	5.4	5.58	10	1.3	5.43	10	1.0%	4.10 [-0.73, 8.93]	2017
Preeti et al.,2019(Anterior Component)	2.5	0.8	20	0.15	0.81	20	98.2%	2.35 [1.85, 2.85]	2019
Total (95% CI)			**40**			**40**	**100.0%**	**2.39 [1.90, 2.89]**	

Heterogeneity: Tau² = 0.00; Chi² = 1.76, df = 2 (P = 0.41); I² = 0%

Test for overall effect: Z = 9.48 (P < 0.00001)

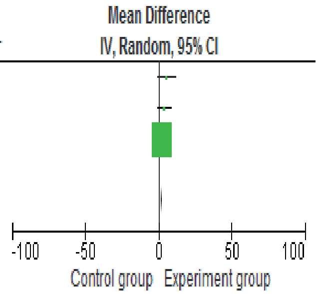


Figure 3. Mean difference and standard deviation change of anterior component of Y-balance test

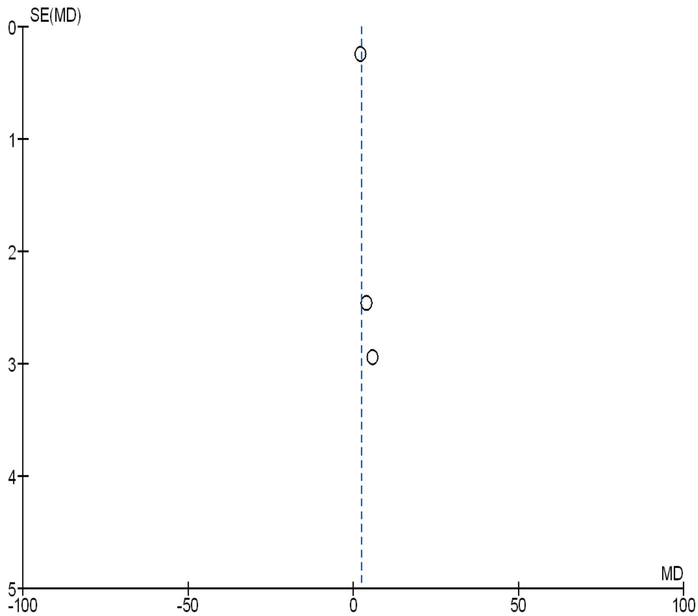


Figure 4. Funnel plot showing no publication bias in the anterior component of the Y-balance test

Study or Subgroup	Experimental Mean	Experimental SD	Experimental Total	Control Mean	Control SD	Control Total	Weight	Mean Difference IV, Random, 95% CI	Year
Ozmen T.,2016 (Posteromedial Component)	5.69	4.01	10	1.15	5.03	10	22.6%	4.54 [0.55, 8.53]	2016
Hamed et al.,2017(Posteromedial Component)	7.9	7.66	10	1.6	8.33	10	9.4%	6.30 [-0.71, 13.31]	2017
Preeti et al.,2019 (Posteromedial Component)	2.03	0.14	20	0.19	0.63	20	68.0%	1.84 [1.56, 2.12]	2019
Total (95% CI)			**40**			**40**	**100.0%**	**2.87 [0.55, 5.19]**	

Heterogeneity: $Tau^2 = 2.03$; $Chi^2 = 3.29$, df = 2 (P = 0.19); $I^2 = 39\%$
Test for overall effect: Z = 2.43 (P = 0.02)

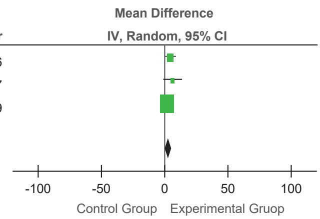


Figure 5. Mean difference and standard deviation change of Posteromedial component of Y-balance test

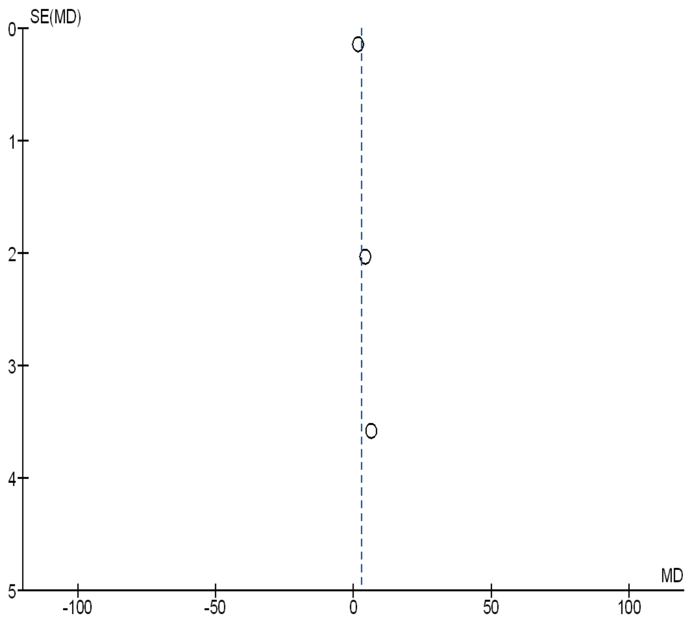


Figure 6. Funnel plot showing no publication bias” in the posteromedial component of Y-balance test

	Experimental			Control				Mean Difference	
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI	Year
Ozmen T.,2016 (Posterolateral Component)	4.78	5.17	10	1.42	5.86	10	19.9%	3.36 [-1.48, 8.20]	2016
Hamed I.et al.,2017(Posterolateral Component)	9.2	7.43	10	1.3	7.47	10	12.5%	7.90 [1.37, 14.43]	2017
Preeti et al.,2019 (Posterolateral Component)	2.23	0.82	20	0.11	0.83	20	67.6%	2.12 [1.61, 2.63]	2019
Total (95% CI)			**40**			**40**	**100.0%**	**3.09 [0.54, 5.65]**	

Heterogeneity: Tau² = 2.45; Chi² = 3.23, df = 2 (P = 0.20); I² = 38%

Test for overall effect: Z = 2.37 (P = 0.02)

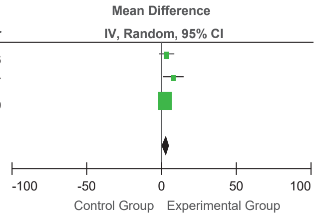


Figure 7. Mean difference and standard deviation change of posterolateral component of Y-balance test

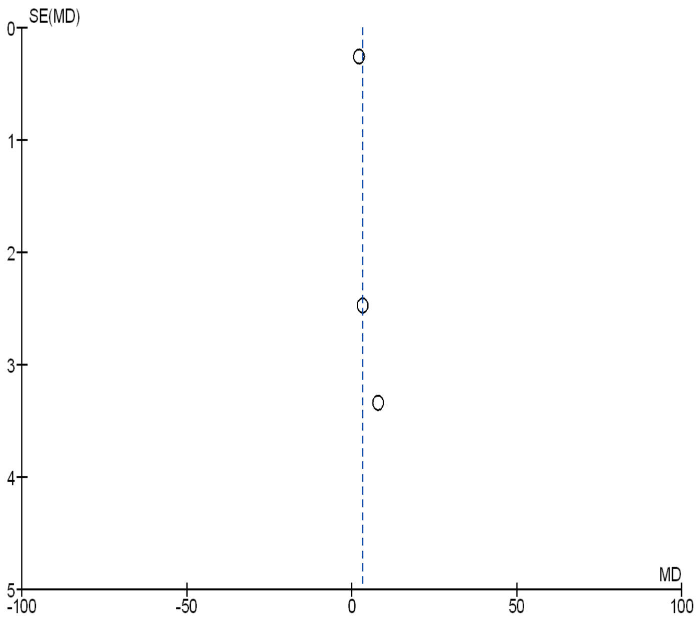


Figure 8. Funnel plot showing no publication bias in the posterolateral component of the Y-balance test

	Experimental			Control				Mean Difference	
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI	Year
Alikhani R.et al.,2019	7.8	7.11	12	-2.32	6.98	10	42.9%	10.12 [4.21, 16.03]	2019
Amirkolaei A.A.S.et al.,2019	12.24	6.8	16	4.97	7.15	13	57.1%	7.27 [2.15, 12.39]	2019
Total (95% CI)			**28**			**23**	**100.0%**	**8.49 [4.62, 12.36]**	

Heterogeneity: Tau² = 0.00; Chi² = 0.51, df = 1 (P = 0.47); I² = 0%
Test for overall effect: Z = 4.30 (P < 0.0001)

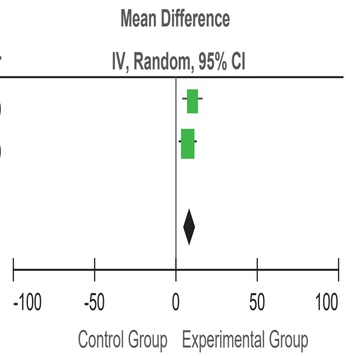


Figure 9. "Mean difference" and standard deviation change of overall Y-balance test

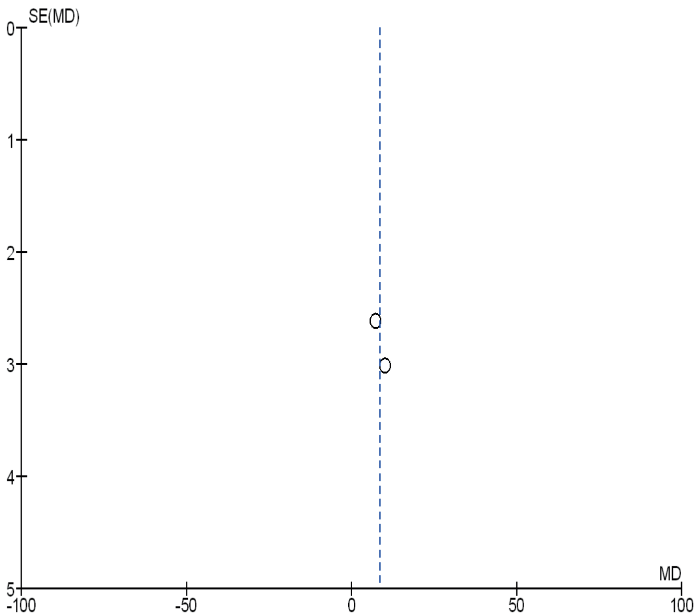


Figure 10. Funnel plot showing no publication bias in overall Y-balance test

Discussion

Low back pain, knee valgus, lower limb injuries, interruption of energy transmission, and decreased performance may occur due to trunk imbalance, weak or poor core muscles strength, which ultimately predisposes the individuals to injury (Kimura et al., 2014; Lee et al., 1999; Nesser et al., 2008; Richardson et al., 1999).

In this meta-analysis, exercise protocols resulted in statistically significant improvement in balance. So, these exercise protocols can play an important role in strength training protocols in badminton players to improve their performance. Many previously published studies support these results (Hassan, 2017; Alikhani et al. 2019; Kalra et.al., 2019; Ozmen, Aydogmus, 2016; Amirkolaei et al., 2019; Sighamoney et al., 2018; Srivastav et al., 2016; Watson et al., 2017; Sandrey, Mitzel, 2013) whereas some of the previous studies are antithetical to our results (Arazi, 2012; Sato, Mokha, 2009).

Core stability can increase muscle strength, endurance, balance, intersegment spinal control, global muscular control of trunk movement, and intra-abdominal pressure (Sedaghati, Sarlak, Saki, 2018; Harati, Daneshmandi, Shahabi Kaseb, 2018; Nesser et al., 2008; Hassan, 2017; Ozmen, Aydogmus, 2016; Sighamoney et al., 2018; Srivastav et al., 2016; Watson et al., 2017; Sandrey, Mitzel, 2013) . Core stability training causes muscle hypertrophy by increasing the number and size of myofibrils, the density of capillaries, the density of tendon nerves and ligaments, and the total contractile proteins, particularly myosin contractile proteins. Because of the alterations in muscle fibers, the pace of muscular contraction did not increase (Modi, Bhatt, 2017).

Plyometric training aids in the development of proper landing techniques and the improvement of dynamic control of the center of mass (COM), resulting in improved neuromuscular adaptation (Popa, Oravițan, 2017). Pilate's training can increase the body's deep sensory approach, which leads to greater balance (Johnson, Larsen, Ozawa, Wilson, Kennedy, 2007). Core muscles provide a firm biomechanical systematic platform for muscles" of the peripheral to act. Proximal to the distal pattern is indicated by assessment of throwing, striking & hitting with segmental sequencing (Marshall, Elliott, 2000) "Pelvic and abdominal muscles are the segmental links of the kinetic chain that connect the lower and upper bodies" "They work as a fulcrum, with the upper and lower bodies serving as movable levers" (Faries, Greenwood, 2007).

Although many studies are proved the effectiveness of core strengthening in improving balance & other exercise parameters which are in sink with the current study but some studies are contradictory to the present meta-analysis. These discrepancies could be attributed to variances in training intensity, plyometric drills, dynamic balance measurement methodologies, gender, and sample population years of experience, the age of subjects and different training programs and as subjects in the growing phase can better improve their motor skills (Arazi, 2012; Sato, Mokha, 2009).

This "meta-analysis and systematic review corroborate that exercise protocols are effective in increasing balance". Exercise Protocols like core stability training, Pilates, plyometrics, and Swiss ball training help improve balance in badminton players, reduce the risk of injuries, and increase the performance of badminton players.

There are several noteworthy aspects to this "meta-analysis and systematic review". This is the first review study as per our knowledge that evaluates the impact of exercise protocols on badminton players' balance. Second, all of the studies that were included had a lower risk of bias and were of greater quality. Finally, because RCTs are the gold standard in experimental research, we only included them in our study. Furthermore, there is no publication (Figures 2, 4, 6, 8).

Despite these advantages, there were several drawbacks to this research. Although we contacted the authors of numerous researches to get missing data, we were forced to omit studies due to a lack of information. We have a smaller number of studies for Meta-analysis.

The clinical implications of this systematic review and Meta-analysis are significant. A weak core disrupts energy flow, resulting in decreased athletic performance and a greater risk of injury to a muscle group that is weak and undeveloped. The primary goal of the training programmer should be trunk strength to develop an athlete's full strength and power potential. The meta-analysis' findings give early evidence that workout programmers that include core strengthening can improve badminton players' balance.

Conclusion

Results of "meta-analysis suggest that exercise protocols result in significant improvement in balance" in Badminton players. Further, comparisons and optimization of these exercise protocols are warranted in future studies.

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VALIDATION AND IMPLEMENTATION OF GENERAL AND SPORT NUTRITION KNOWLEDGE QUESTIONNAIRE FOR UNIVERSITY STUDENTS AND ATHLETES

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Abstract The aim of the present study was to validate and implement a nutrition questionnaire to measure nutrition knowledge of university students, and athletes. Male, and female students (N = 476) voluntarily participated in the survey in 2019. Non-health related (n = 156), nutrition students (n = 163), and varsity athletes (n = 157) responded to the questionnaire, twice with 15 days' interval between. In this study, new “General and Sport Nutrition Knowledge” (GSNK) and, two other “Short General Nutrition Knowledge” (SGNK) and, “Short Sport Nutrition Knowledge” (SSNK) questionnaires were used to determine the validation of the survey. One-way ANOVA, t Test, Pearson correlation coefficient, and Cronbach's α statistics were used to evaluate validity and reliability ($p < 0.05$). The Internal consistency, test-retest reliability, concurrent validity with two similar tools, and construct validity among the groups of students for nutrition knowledge were employed throughout the data analysis. Nutrition students outperformed in all nutrition knowledge sections. Respectively, athletes were the second, and non-nutrition related students were the third in sport nutrition ($p < 0.05$). With regard to general and total nutrition knowledge scores, female students performed significantly better than males ($p < 0.01$). Modified questionnaire was found to be valid, reliable, and suitable tool for Eurasian university students, and athletes. Results also illustrated that the intermittently nutrition educations are required for athletes, as it is recommended in related literature.

Key words nutrition knowledge, modified survey, validation, university athletes

Introduction

An increased level of nutrition knowledge can have a positive effect on having appropriate nutrition behaviours and dietary habits and may be effective in preventing unbalanced and unhealthy diets caused by various reasons (Alkaed, Ibrahim, Ismail, Barake, 2018; Spronk, Kullen, Burdon, O'Connor, 2014). Because of the particular needs in sport such as increased energy requirements, sports players have been in search for a diversity of food, utilizing different types of diets, and taking supplements in able to increase their sporting performance. Such situations demonstrate the importance of having a good nutritional knowledge for both a general healthy life, and for long-term sport life of athletes (Calella, Iacullo, Valerio, 2017; Potgieter, 2013).

Increasing the level of awareness in nutrition knowledge will affect young and adult athletes in a positive way (Dascombe, Karunaratna, Cartoon, Fergie, Goodman, 2010). In this context, there is a need for scientific measurement tools that will measure and determine the level of nutritional knowledge of persons, according to their related cultures and environment (such as; religions, nationalities, geography). Most previous scales have not been fully validated taking into account these cultural respects (Alkaed et al., 2018; Bradette-Laptante et al., 2017; Calella et al., 2017; Guadagnin, Nakano, Dutra, Carvalho, Ito, 2016; Karpinski, Dolins, Bachman, 2019; Trakman, Forsyth, Devlin, Belski, 2016).

Unlike the previous questionnaires which are either for general nutrition knowledge or sport nutrition knowledge (Karpinski, et al., 2019; Hendrie, Cox, Coveney, 2018; Zinn, Schofield, Wall, 2005) a more comprehensive and psychometrically developed and validated questionnaire including both general and sport nutrition knowledge (GSNK) was administered as of the high school level population in Italy (Calella et al., 2017). Yet this tool was not validated within university athlete populations up to now, thus whether or not the scores are truly indicative, and suitable in this population is under scrutiny. However, that questionnaire was the best available option at the time of research, and contained both general and sport nutrition sections (Werner, Guadagni, Pivarnik, 2020).

The development of a new questionnaire modified from the general and sport nutrition questionnaire previously mentioned could be a more useful tool for Eurasian countries' athletes, scientists, nutritional professionals, and coaches who mostly have Islamic cultures.

The purpose of this study, therefore, was to establish, and test a more valid, and reliable nutrition knowledge instrument for university students, and athletes, so it will have been used not only for common in Western, but also Eastern countries.

Material and methods

Participants

The study sample consisted of students from the "University of Istanbul Sabahattin Zaim" (private university) "University of Istanbul Gelisim" (IGU, private university), "Marmara University" (MU, state university in Istanbul), "Istanbul University" (IU, state university), and "Kirikkale University" (KU, state university in middle Anatolia), mean age 22 ±1,8 (17–35) years, who volunteered to participate in the study without receiving any payment. The students (N = 476) were selected based on their educational disciplines (non-health related and nutrition), and whether or not they were competitive athletes. All the subjects who participated in the study voluntarily were not given any special nutrition education before the questionnaire applications.

Besides the comparisons among the results of questionnaire between the three different groups, (nutrition-educated, non- nutrition educated student, and athletes); one other comparison was also made between the students of team sports (n = 101) and individual sports (n = 56). Moreover, an additional comparison was done between the dietitian students of first year, (n = 77), and fourth years (n = 86) for construct validity (n = 163) (Table 1).

Table 1. Demographic Characteristics of Study Groups, by Social, Sports and Academic Background Status. N, (%), (Means ± SD), M (Male), F (Female)

Groups characteristics		Non-Health university students (n = 156)	Nutrition/Diet students (n = 163)	Varsity athletes (n = 157)	All subjects total (n = 476)
Age (year)		21.7 ±1.8	21.3 ±2.2	21.8 ±2.2	21.5 ±2.1
Sport experience (year)		–	–	7.3 ±4.5	–
Height (cm)	M	178 ±10	176.9 ±4	180.3 ±9	179.2 ±8*
	F	164 ±11	164.5 ±5	166.0 ±7	164.7 ±6
Weight (kg)	M	75.6 ±13	74.4 ±10	78.1 ±12	76.9 ±12*
	F	58.1 ±9	56.1 ±7	60.4 ±8	57.3 ±8

Nutrition Training Come from (%): 1; School programs, 2; My Teachers, 3; Outside the school, 4; My family 5; My Coaches, 6; TV Watches, 7; Internet, 8; My friends, 9; Others; 10; No training and knowledge.
* Significant Differences among groups $p < 0.05$.

Expert panel evaluation

“General Nutrition Knowledge” and “Sport Nutrition Knowledge” items were developed by modifying an existing questionnaire for athletes, and general students (Calella et al., 2017).

A preliminary item pool was generated from an expert panel composed of three registered dieticians, and two sport scientists with expertise in nutrition and sport. The panel was then extended to include a food engineer, a food scientist, and finally one psychologist selected to assess the items.

Procedures

The panel evaluated the questionnaire for content validity with rigorous assessment of the items for representation of nutrition knowledge. The acceptable level for content validity was set >80 percentage, as considered the minimum value (Bradette-Laptante et al., 2017). Expert panellists reviewed the last version of the questionnaire; they discussed and approved the pilot version of the questionnaire.

Internal Consistency Phase – The internal consistency for each section was calculated using the Cronbach’s alpha, which is recommended as score of above the 0.7 for the minimum requirement (Dascombe et al., 2010).

Test – Retest Reliability Phase – To determine the reliability of the GSNK questionnaire, test-retest analysis was conducted by getting the same subjects to complete the same questionnaire two weeks after the initial questionnaire (Dascombe et al., 2010). Pearson’s correlation was used to determine the test retest reliability. From the initial subject of 320 students, only 254 (79.3%) of them completed the GSNK questionnaire twice.

Concurrent Validity Phase – In addition, concurrent validity was computed using Pearson’s correlation between the GSNK, and the two other questionnaires for “Short General Nutrition Knowledge” (SGNK), (Islamoglu et al., 2019) and, for athletes’ “Short Sport Nutrition Knowledge” (SSNK) (Dascombe et al., 2010).

Construct Validity Phase – Construct validity was assessed by administering the GSNK questionnaire to three groups of university students who were expected to differ in their nutrition and sport nutrition knowledge. Dietetics/

Nutrition students, Athletes, and non-health related students (From the universities of MU, KU, IZU, IGU, and IESU). No incentives were given and the recruitment was performed at a suitable time at the end of a lecture. All three questionnaires were administered at a single session. The flow chart illustrating our analytical strategy and the details of the validity procedure were presented in Figure 1.

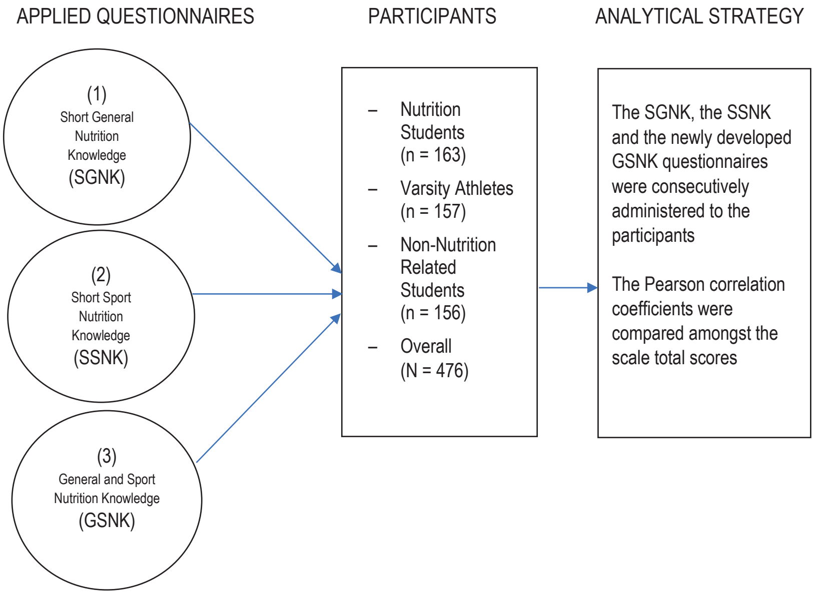

Figure 1. The flow chart of the questionnaire for validity procedures

Pointing the Questionnaires, Test results – All scores were coded in questionnaire as "1" for a correct answer and "0" for incorrect or the 'I don't know' reply. There were a total of 103 items in the Questionnaire (GSNK); 69 items in the general nutrition section and 34 items in the sport nutrition section. The maximum score of questionnaire was 103, and the minimum was 0.

Minor changes and additions done on the new questionnaire of the (Calella et al., 2017) – A question to determine the "sport experience" had not been included in the personal information section of original questionnaire was added in new one, so that it would be possible to determine the relationships between years of experiences on nutritional knowledge of persons'. Several other questions were revised or added to reflect the dietary habits of the Predominantly Islamic and Middle Eastern populations. One question (question 1, option 1) was revised inquired about the use of swine-related meat products. The reference to such meat products ("boiled ham" or "jambon") was replaced with meat products more extensively utilized by this population. Questions that were added include one (question 7) related to spinach that is abundantly used as source of plant food and one (question 8) about 'banana', which is a source of potassium.

Statistics

Group comparisons were done via one-way ANOVA test, on the knowledge scores of subjects for total general nutrition knowledge and sport nutrition sections to assess the three groups. Internal consistency of the adapted new instrument was measured using Cronbach-α reliability coefficient to evaluate how consistently items within each section of the instrument and overall score assess the knowledge. Cronbach- α values range from 0 to 1, with this scale indicating the consistency of responses. Pearson's correlation was used to assess the test-retest reliability of the GSNK. A score of 0.7 or greater is considered satisfactory for both internal consistency and reliability. The concurrent validity was also determined, via Pearson Correlation between GSNK questionnaire and the other two short but similar questionnaires (SGNK and SSNK). It was also used to determine the relationship of years of experiences and sport nutrition knowledge of athletes. Independent samples t-test and paired samples t-test were also used for comparison of independent binary groups (between team and individual sport athletes) and comparison of test-retest mean scores of the participants. Statistical tests were two-sided and differences at $p < 0.05$ were considered significant. All statistical analyses were performed using the Statistical Package of Social Sciences (SPSS, Chicago, IL, USA) for Windows software program (version 25.0).

Ethics Approval

The researchers obtained approval from the Ethics Committee of the Istanbul Sabahattin Zaim University for the study protocol, and written informed consents were obtained from the participated subjects complied with the Helsinki Declaration.

Results

The extended experts' panel received the questionnaire by hand and reviewed the items according to guidelines in Appendix A to meet the minimum required for clarity, interpretability, content importance, and pertinence. After this qualitative review, a face-to-face meeting was performed on the whole questionnaire. After discussing the items, a final version of the questionnaire composed of 103 items was approved.

Twenty questionnaires were not taking into consideration in the research by the investigators, as they did not complete questionnaire as directed. As it stands, the total sample was composed of 476 students (Female: 262; Male: 214).

There were no significant differences between male and female students in the section of sport nutrition knowledge ($p > 0.05$). However, general, and total nutrition knowledge scores of female students were significantly better than males ($p = 0.001$) (Table 3). There was no significant difference in terms of nutrition knowledge in both general knowledge section ($p = 0.55$), and sport nutrition section ($p = 0.71$) between individual sports athletes and team sports athletes.

There were no significant high-level correlations between sports years of experience, and nutrition levels of athletes ($r = -0.14$; $r = -0.16$) ($p < 0.05$) (Table 2). According to correlation calculations, the education level of parents did affect the nutritional knowledge of the subjects significantly ($r < 0.15$) ($p < 0.05$).

Total knowledge scores of all subjects in correctly answered items were averaged at 60 ±18 % as the evaluation of success rate. Scores of success as percent were 74 ±12% for nutrition students, 52 ±10% for university social science students, and 53 ±9% for varsity athletes differing significantly ($p = 0.04$). At each knowledge section, correct responses as a percentage, ranged from 50 ±14% to 74 ±12% in total, with no significant differences between varsity athletes, and control students in general nutrition section. However, athletes had better results than control group of non-nutrition related students ($p < 0.05$).

Internal Consistency – Cronbach's alpha values of questionnaire items were calculated at 0.89 for total questions (both of general and sports knowledge sections), 0.88 for general nutrition section, and 0.72 for sport nutrition sections (p = 0.12–0.90).

Test-Retest Reliability – Pre and post-test reliability for the general nutrition section of questionnaire was 0.90, and sport nutrition was 0.89, and reliability for the total questionnaire was 0.92. These coefficients of "r" were not only higher than the reported statistical acceptance of >0.70, but also as high as some other reported related studies (Dascombe et al., 2010).

Concurrent Validity – Correlations were determined between two other similar questionnaires with our general and sport knowledge results were shown in Table 2.

Table 2. Correlations of Developed GSNK Questionnaire with two Different Questionnaires on Nutrition Knowledge

n = 296	GSNK general nutrition	GSNK sport nutrition	GSNK total
Short general nutrition knowledge questionnaire (SGNK)	0.70*	0.51*	0.70*
Short sport nutrition knowledge questionnaire (SSNK)	0.55*	0.45*	0.56*
General nutrition knowledge questionnaire (GNK)	0.71*	0.51*	0.70*
Sports years of experience	–0.14	–0.16	–0.15

* Correlation is significant at the *p < 0.01* level (2-tailed).

Source: Zawilla et al. (2003); Islamoglu et al. (2019).

High correlation coefficients were found between the Zawila, Steib, Hoogenboom (2003), and our sport nutrition knowledge result. Additionally, there were high correlation between the sport knowledge scores, and the short questionnaire by Islamoglu, Basoglu, Ozbey, Tosya, Gunes (2019). Correlations in this study were also higher than the study of Calella et al. (2017).

Construct Validity – Construct validity results were shown in Table 3. Knowledge scores of nutrition students were significantly better then two other groups, however there was no significant differences between athletes, and non-nutrition related students in general nutrition knowledge (p = 0.001), according to statistical difference tests of One – Way ANOVA and Tukey. The group of dietetics showed significant highest mean results both in

Table 3. Nutrition knowledge scores of tested university students and athletes

Groups	Sport Nutrition Score	General Nutrition Score	Total Nutrition Score
Nutrition Students n = 163	21.6 ±4.3*	55.1 ±8*	76.7 ±11*
Varsity Athletes n = 157	18.1 ±4.8*	39 ±10	57.1 ±14*
Non-Nutrition Related Students n = 156	15 ±5.6*	37 ±11	52 ±14*
Males n = 214	17.8 ±5.4	39 ±12**	56.8 ±16**
Females n = 262	18.7 ±5.7	48 ±12	66.5 ±17
Total subjects N = 476	18.3 ±5.6	44 ±12	62.1 ±17

* Significant differences among groups according to One Way Anova Test calculator ($p < 0.05$).
** Significant differences between groups according to Independent T Test calculator ($p < 0.05$).

general, and sport nutrition sections of the GSKN scores ($p = 0.001$). However, athletes' sport nutrition scores were significantly higher than non-health related university students ($p < 0.05$). These results support the hypothesis that sport nutrition section of the questionnaire measures the nutrition knowledge of the competitive athletes effectively when applied to the athletes (see Table 3). Therefore, our nutrition knowledge questionnaire can be accepted as valid to measure for all type of university student.

Discussion

The aim of this study was to validate a general and sport nutrition knowledge questionnaire modified from the recent comprehensive GSNK questionnaire for both general university students and athletes (Calella et al., 2017).

The questionnaire used in this study reported a high level of acceptance for validity, and showed high level of reliability when using for university students and competitive university athletes in general nutrition sport nutrition, and total knowledge. Results were comparable to those of observed in similar studies (Alsaffar, 2012; Matsumoto, Tanaka, Ikemoto, 2017).

After thorough investigation of the literature, it was discovered that the sample size used in this study had the largest number of subjects, amongst similar studies (Table 1). So, the demographic population used in this study can be accepted as highly representative level for all type of university students and athletes in all over the world. Although the version of the questionnaires used were in the Turkish language, an English version of it was also prepared by the researchers, experts have been found it also as useful for the similar countries populations all over the world.

This research is found important in that it present a comprehensive and validated tool, to determine the general nutrition and sport nutrition knowledge of university students, and athletes. In addition, is not only for Western Cultures, but can also be beneficial for Asian countries as well, due to being modified to be relevant to their specific culture (Dascombe et al., 2010).

By means of this tool, researchers, practitioners and coaches can make tests to determine and assess the nutrition knowledge. They can also search the relations between knowledge, and behaviours of different level of populations and groups. Based on these types of studies, researchers can also develop similar new tools for different populations; such as for elite and amateur athletes, elderly peoples, obese, and disease people (Leavey, Strawderman, Jones, Port, Held, 1998).

In a recent review article, Trakman et al. (2016) analyzed 36 studies related with nutrition knowledge, and reported that none of them covered all sections of nutrition. However, the recently developed tool in Europe was found to be one of the most comprehensive questionnaires with exception of knowledge regarding alcohol, especially within Islamic cultures. Because of this, we used it as reference, and covered the most of the psychometric validation process, and requirements inside it (Dascombe et al., 2010).

We have added to our new questionnaire some items of food related with green leafy vegetables for diet fibres content, processed meat for salt content, and cheese for calcium content, spinach for iron content and banana for potassium content. We used also some common cultural expressions with some changes, from the original. Terms such as "salami, soujouk, and sausage, without ingredient of pork product" were used instead of "boiled ham, or jambon", and "whey cheese" instead of "ricotta".

As we hypothesized, the nutrition group acquired significantly the highest score out of all other groups in general, sport and, total knowledge ($p < 0.01$). General nutrition knowledge of the athletes, was not differing significantly then general students ($p > 0.05$), it was found notable. In according to group-based comparisons showed that, values of the nutrition related students have better results than social students, and athletes, in all knowledge categories with a significant difference.

These informative results are similar with previous investigations related to nutritional knowledge in US, and Germany (Silveira et al., 2015). However, some of the values in these studies were better than what we discovered. These findings may be the result that our population may have lowers years of experience than in the other papers, or that our population was found to be younger than those of the adult subjects were.

In our sample, females scored significantly higher than males for both the total survey, and general nutrition section (Table 3). However, in sport nutrition scores, there were no significant differences between genders. There is current information in the literature about whether there are significant differences in nutrition knowledge between sexes (Dascombe et al., 2010). In athlete populations, some studies have reported that female athletes have higher nutrition knowledge than males, while others have reported no significant differences between the sexes similar to ours (Dascombe et al., 2010). These conflicting results could be attributed to both the different knowledge assessment tools being used, as well as their passed education, and interest differences to nutrition, between the two sexes. The percent success rate of this study indicates that, university athletes, and students sometimes showed low knowledge, some are medium, and some of the results were the higher in nutrition knowledge, comparing to the reported literatures in elite, and college athletes (Dascombe et al., 2010). However, inter-student and inter-athletes' different variability suggests a need for a specified nutrition education.

Fourth-year students of dietetics and nutrition department in this study had also significantly successful than first-class students. These findings also supported our conclusion that the questionnaire is selectable, and able to differentiate the level of nutrition knowledge, as like in the similar studies (Dascombe et al., 2010).

Reliability calculations in this study ($r = 0.89–0.92$) were done by using large samples demonstrated satisfactory performance. These results suggest that new GSNK questionnaire had good external reliability, similar to the related literature (Calella et al., 2017; Trakman et al. 2016, Bukenya et al., 2017).

Our developed questionnaire showed moderate and high correlation with two chosen nutritional knowledge questionnaires from the literature ($r = 0.45$ to 0.71) to assess concurrent validity (Table 2). However, Correlation coefficients between two different tested tools were not found to be high. It could infer from this result that different measurement tools used in validity research have measured nutrition knowledge, in different levels, owing to their characteristics (Dascombe et al., 2010).

Nutrition knowledge levels of university athletes were found not different from the control group of non-nutrition related students ($p > 0.05$). Additionally, nutrition knowledge was not related with the sport experience of them ($r = 0.14$ for general nutrition; $r = 0.16$ for sport nutrition) ($p < 0.05$). From these results, it was concluded that the intermittently nutrition educations are required of athletes, as recommended in related literature (Blennerhassett, McNaughton, Cronin, Sparks, 2019; Birkenhead, Slater, 2015; Zieff, Veri, 2009; Torres-Mcgehee et al., 2012).

Conclusion (practical applications)

This up to date and scientifically confirmed comprehensive questionnaire (GSNK) can be used as test tool in Euro-Asian countries. It can be also used into determine the relationship between general, and sport nutrition knowledge, as well as sport experience, education level, socio-economic properties, physical fitness characteristics, sports performance, and dietary behaviours for future research studies. By means of this new developed tool, coaches, and dieticians can assess the subjects' nutritional knowledge status. Tool may also assist, in the planning of nutrition education programs for different groups of students and athletes.

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