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Investigation of the relationship between strength and dynamic balance performance in elite wrestlers

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Abstract
Background. Wrestlers rely heavily on the abilities of strength and balance to ensure success. Although previous studies have investigated the effects of different training methods on the athletic performance of strength and balance, there are a limited number of studies aimed at examining the relationship between these two performances.
Problem and Aim. The purpose of this study was to examine the association between the variables of dynamic balance and dynamic muscle strength (isokinetic strength of the knee extensors and flexors).
Methods. Thirty elite wrestlers age range 17 to 25 participated in this study (age: 21.7±2.6 years, height: 176.2±5 cm, weight: 78.3±11.2 kg). Biodex Balance System (BBS, Biodex Medical Systems Inc., Shirley, NY) was used to test dynamic balance, and three index scores were recorded as an overall stability index (OSI), an anterior-posterior stability index (APSI), and a medial-lateral stability index (MLSI). Strength measurements were conducted using an isokinetic dynamometer (Cybex, Humac Norm 2004). Pearson correlation was performed to determine the relationships, and the significance level was set at $p < 0.05$.
Results. No significant correlations were observed between the variables of postural balance and strength ($p>0.05$).
Conclusions. The findings of this study support the hypothesis that dynamic balance and leg muscle (hamstring and quadriceps) strength are independent of each other.

Introduction

Sports performance is dependent on the high level of technical skills and the level of development of fitness components [Gorucu *et al.* 2017]. Like most combat sports, wrestling which is a popular sport necessitates strength, endurance, and balance. Wrestlers aim to improve performance components of strength and balance to reduce injury risk and increase their athletic performance [Muehlbauer *et al.* 2013; Ringsberg *et al.* 1999]. Although it is known that dynamic/static balance and strength are two performances that can reduce the risk of sports injuries and increase athletic performance [Fousekis *et al.* 2011], understanding the relationships of these performances with each other can be important in field setting [Muehlbauer *et al.* 2013; Muehlbauer *et al.* 2012], However, few studies have focused on this topic. The previous studies have methodological differences concerning cohorts and measurements, thus making comparisons across studies more challenging; however, discussing them in terms of applied methods and selected cohorts can bring up new research questions. While some studies have reported significant associations between balance and strength [Spink *et al.* 2011; Behennah *et al.* 2018; Hammami *et al.* 2016; Ambegaonkar *et al.* 20014], others have shown that there is no significant relationship

between the variables of strength and balance. The above-cited studies together with an additional meta-analysis study [Muehlbauer *et al.* 2015] have already extended the knowledge regarding the relationship between strength, power, and balance performance. Moreover, it is indicated in that meta-analysis that there are some critical factors such as age/maturation and training experiences that may have effects on the associations between strength and balance [Muehlbauer *et al.* 2015]. To the best of our knowledge, there is no study to examine the relationship between isokinetic knee extensor/flexor strength and dynamic balance in elite athletes. This study aimed at examining the relationship between performances of isometric strength and dynamic balance focusing on elite wrestlers aged 17-25.

Methods

Subjects

Physical characteristics of the thirty wrestlers who participated in this study voluntarily. Only Greco-Roman wrestlers participated in the study. Wrestlers played in national and international tournaments repeatedly. Participants were informed about the aim and the risks of the study. All participants provided written informed consent. The study protocol was approved by the Ethics Committee.

Table 1. Participant demographics

	N	Min.	Max.	Mean	Std. deviation
Age (y)	30	17	25	21,70	2,562
Body height (cm)	30	164	188	176,23	5,667
Body mass (kg)	30	62	105	78,30	11,216
Body mass index ($kg.m^{-2}$)	30	18,12	35,22	25,21	3,47

For body weight (BW), since there were the non-homogeneous distribution, high standard deviation(11.22) and significant correlation between BW and the variables of strength ($r=0.562$, $p<0.01$ for KEs and $r=552$, $p<0.01$ for KFs), relative values for strength parameters were calculated separately to control the effect of BW on results.

Procedure

Participants were taken to the sports science faculty laboratory at 11.00 am. Participants were warned not to participate in any exercise in the past 48 hours until the end of the test section. Subjects were applied to standard warm-up including stretching movements. Following that, participants' dynamic balances were taken by Biodex Balance System (BBS, Biodex Medical Systems Inc., Shirley, NY). The participants who completed the balance test were then immediately taken to the isokinetic knee strength test. A 5-minute rest period was given between isokinetic strength knee test [Miller, Croce 2007].

Dynamic Balance Testing

The participant's dynamic balances were measured with open eyes. Two tests were performed on each participant to get used to the measurement instrument before the measurement, and then two more measurements were made for both the dominant and the non-dominant leg. Subjects were subjected to a balance test on one foot by holding their hands on the shoulders of the crossed position after standing on the BBS's mobile platform. The level of difficulty of the measuring instrument was set to "Level 5" for the OE condition. The other leg did not touch the ground and participants were not allowed to look at the BSS monitor [Bayraktar 2017]. 3 separate balance scores were obtained after the automatically completed test [Overall Stability Index (OSI), Anterior-Posterior Index (APSI), Medio-Lateral Index (MLSI)].

Isokinetic Strength Testing

The isokinetic knee strength measurements were performed with an isokinetic dynamometer (Cybex, Humac Norm 2004) in the kinanthropometry laboratory of Selcuk University. Wrestlers participating in the study were taken to the isokinetic knee test after warming up. Participants were seated in the correct position in the test seat. The participants' holders and the middle sections of the thighs were stabilized to the seat by the tapes. In addition, they were allowed to support by holding the handles on the right and left sides of the seat during the test.

Five repeat maximal contractions knee extension (hamstring) and flexion (quadriceps) torque values were obtained at $60° \text{ sec}^{-1}$ speed. Peak power and average power of both legs were recorded. Participants were supported by verbally encouraging expressions in order to achieve higher performance during the test. The best values were recorded.

Statistical Analyses

Pearson correlation was performed to check the relationship between the variables of strength and dynamic balance scores. Data were provided as the mean (M) and standard deviation (SD). All statistical tests were performed using the software package SPSS version 22.0 (SPSS Inc, Chicago, IL). The statistical significance level was set at $p < 0.05$.

RESULTS

Descriptive statistics concerning the variables of strength and dynamic balance are presented in Table 2.

Table 2. Descriptive Statistics for the variables of strength and dynamic balance

	N	Min.	Max.	Mean	Std. deviation
Stability Indices					
OSI	30	1,50	3,40	2,2433	,47611
APSI	30	,80	2,60	1,6600	,46727
MLSI	30	1,00	2,20	1,4600	,31579
Isometric strength					
KEs	30	164	302	239,57	32,506
KFs	30	58	178	130,30	24,751
REL.KEs	30	2,26	3,77	3,0853	,39423
REL.KFs	30	,77	2,07	1,6721	,27009

Note: KEs and KFs= maximum voluntary isokinetic knee extensor and flexor strength; REL= relative values (N·m·kg-1); OSI= Overall Stability Index; APSI= Anterior–Posterior Stability Index; MLSI= medial–lateral stability index

Table 3 presents Pearson correlation coefficients and significance levels for the variables of strength and dynamic balance.

Table 3. Correlation between the variables of strength and dynamic balance.

Dynamic Balance		Isokinetic strength (peak torques)			
		KEs	KFs	REL.KEs	REL.KFs
OSI	Correlation	-,113	-,009	-,110	-,027
	p	,552	,963	,563	,886
APSI	Correlation	-,028	-,096	-,047	-,159
	p	,884	,614	,804	,401
MLSI	Correlation	-,150	-,069	-,317	-,192
	p	,430	,719	,088	,309

Note: KEs and KFs= maximum voluntary isokinetic knee extensor and flexor strength; REL= relative values (N·m·kg-1); OSI= Overall Stability Index; APSI= Anterior–Posterior Stability Index; MLSI= medial–lateral stability index

There were no statistically significant correlations between the variables of strength and dynamic balance ($p>0.05$).

Discussion

This study revealed that non-significant associations between dynamic balance and knee extension/flexion strength/power in elite wrestlers. Since the previous studies investigating the relationship between strength and balance have methodological differences, it is difficult to discuss our findings in relation to them. While some studies have used dynamic balance measurements, others have applied different tests of static balance. The studies considering dynamic balance have also used different types of dynamic balance (different balance platforms, Star Excursion, or Y Balance Tests). The Biodex Balance System which evaluates neuromuscular control by quantifying the ability to maintain postural stability [Karimi *et al.* 2008] was used to determine the dynamic balance values in this study. In addition to balance, the strength measurements have been performed by means of different methods. Even though some studies have used measurements of isometric strength [Behennah *et al.* 2018; Granacher *et al.* 2012; Carter *et al.* 2002], there are also several studies using isotonic or isokinetic equipment [Ageberg *et al.* 2005; McCurdy, Langford 2006].

An overall analysis of studies, disregarding the methodological differences, leads to the conclusion that strength and balance are dependent on each other. The majority of previous studies have reported weak or highly significant relationships between strength and balance [Hammami *et al.* 2016; Ambegaonkar *et al.* 20014, Carter *et al.* 2002; Ageberg *et al.* 2005; Suri *et al.* 2009]. Blackburn *et al.* [2000] found that enhancement of muscular strength is equally effective in promoting joint stability and balance maintenance. In addition to these studies reporting significant relationships between balance and strength, few studies have revealed that there is no significant relationship between balance and strength [Muehlbauer *et al.* 2012; Granacher *et al.* 2012; McCurdy, Langford 2006]. Muehlbauer *et al.* [2013] have shown a non-significant relationship between measures of static/dynamic balance and isometric strength in young adults. Granacher and Gollhofer [2012] stated that these contradictory findings may be the result of variations in research design, including the measurement of postural control and strength with different methods of assessment. Furthermore, the associations between strength and balance can vary by different factors such as age, maturation and training experiences [Muehlbauer *et al.* 2015]. To the best of our knowledge, this study is also the first to examine the relationship between isokinetic strength and dynamic balance in elite wrestlers. As previous studies have included different populations, it may have produced contradictory findings in the literature. Indeed, investigated cohorts in the previous studies have been young, adult or elderly people [Muehlbauer *et al.* 2013; Granacher *et al.* 2010], in patients with anterior cruciate ligament injury [Ageberg, *et al.* 2005], patients with osteoporosis [Carter *et al.* 2002], asymptomatic participants [Behennah *et al.* 2018], and soccer players [Hammami *et al.* 2016].

In this study, the relationship between lower extremity strength (hamstring and quadriceps) and balance were investigated. Based on our findings, dynamic balance and strength appear to be unrelated in elite wrestlers which means these performance components are independent of each other. As with knee extension studies in the lower extremity, squat exercises also reported non-significant findings. McCurdy and Langford [2006] have found that unilateral squat strength is not correlated with unilateral static balance in young adult men and women. Similarly, Muehlbauer *et al.* [2013] have

reported no relationship between squat strength and dynamic balance in young adults.

Conclusion

According to the results of the present study, there is no relation between dynamic balance and strength in elite wrestlers. Therefore, as a practical application, training-induced strength enhancement might not necessarily task for balance. However, there is some evidence pointed out that "hip strength" [Ambegaonkar *et al.* 20014], and "trunk extension strength" [Hammami *et al.* 2016, Suri *et al.* 2009, Suri *et al.* 2011] affect balance performance thus for the future study these parameters can be examined.

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Badanie zależności między wydajnością siły a równowagą dynamiczną u elitarnych zapaśników

Słowa kluczowe: zapaśnicy, wydajność siły, izokinetyka, stabilność posturalna

Streszczenie

Tło. Zapaśnicy w dużym stopniu polegają na sile i równowadze, aby zapewnić sobie sukces. Chociaż wcześniejsze badania sprawdzały efekty różnych metod treningowych związanych z sportowymi osiągnięciami siły i równowagi, tylko ograniczona liczba badań miała na celu zbadanie związku między tymi dwoma wynikami.

Problem i cel. Celem tego badania było zbadanie związku między zmiennymi równowagi dynamicznej a dynamiczną siłą mięśni (izokinetyczną siłą prostowników i zginaczy kolana).

Metody. W badaniu wzięło udział 30 elitarnych zapaśników w wieku od 17 do 25 lat (wiek: 21,7±2,6 lat, wzrost: 176,2±5 cm, waga: 78,3±11,2 kg). Do badania równowagi dynamicznej użyto System Równowagi Biodex (BBS, Biodex Medical Systems Inc., Shirley, NY), w którym odnotowano trzy wskaźniki: wskaźnik ogólnej stabilności (OSI), wskaźnik stabilności przednio-tylnej (APSI) oraz wskaźnik stabilności przyśrodkowo-bocznej (MLSI). Pomiary siły przeprowadzono przy użyciu dynamometru izokinetycznego (Cybex, Humac Norm 2004). Do określenia zależności zastosowano korelację Pearsona, a poziom istotności ustalono na poziomie $p < 0,05$.

Wyniki. Nie stwierdzono istotnych korelacji pomiędzy zmiennymi równowagi posturalnej i siły ($p>0,05$).

Wnioski. Wyniki tego badania potwierdzają hipotezę, że równowaga dynamiczna i siła mięśni nóg (ścięgna podkolanowego i mięśnia czworogłowego) są od siebie niezależne.