ORIGINAL ARTICLE

The Relationship between Laterality and Balance

SEBIHA GÖLÜNÜK BAŞPINAR[1], MEHMET YILDIZ [1]
[1]Afyon Kocatepe University, Faculty of Sport Science, Turkey
Correspondence to Dr Sebiha GÖLÜNÜK başpınar, Email.sgolunuk@gmail.com, Cell:+90 02722281363

ABSTRACT

Background: Laterality preference is important for balance and isokinetic strength.
Aim: To investigate the relationship between isokinetic arm and knee strengths and balance performance with respect to lateral preference.
Methods: Twenty four healthy university students (12 right-handers, 12 left-handers) performed knee flexion/extension strength values at velocities of 60°/s and 180°/sand supination/pronation strength values at velocities of 30°/s and 120°/s using an isokinetic dynamometer. Moreover, they performed static and dynamic balance.
Results: There were high negative correlation between support leg static balance and right arm 30°/s supination strength (r= -0.773 p<0.05) and right arm 120°/s supination strength (r=-0.832, p<0.05) in left-handers. There were moderate positive correlation between support leg static balance and 30°/s supination strength (r= 0.722, p<0.05) and right arm 120°/s supination strength (r=0.551, p<0.05) in right-handers. Similarly, there is a moderate positive correlation between support leg dynamic balance and right arm 30°/s strength (r=0.548, p<0.05) and a moderate positive correlation between dominant leg dynamic balance and left arm 120°/s strength (r=0.624, p<0.05) in right-handers. There is no statistically significant relationship between isokinetic leg strength and static and dynamic balance values in either group.
Conclusion: Arm strength has a positive effect on support leg static balance in left-handers.
Keywords: I**s**okinetic, laterality, balance, relationship, strength

INTRODUCTION

Receiving fast and continuous feedback from visual and vestibular structures, balance somatosensory is defined as a process of maintaining the center of gravity of the body in a vertical position on support followed by smooth and coordinated neuromuscular movements[1,2]. Playing a crucial role in leading a regular and successful life and exhibiting high performance, balance ability is one of the motoric features classified as static and dynamic[3]. Studies conducted specially in the last quarter of a century point to a high correlation between balance ability and disability risk. They also report that balance ability plays an important role in improving performance, maintaining high performance, and selecting and learning skills[1]. In order to achieve balance, the central nervous system must receive and process sensory information, and then provide appropriate feedback. Visual, auditory and proprioceptive sensory components are actively involved in the maintenance of balanc[4].However, the effects of these components on balance may vary according to leg preference (right-handers and left-handers)[5].The term lateral preference refers to the asymmetrical use of bilateral limbs or sense organs that are anatomically symmetrical along the sagittal plane of the body. The most important sign of lateral preference is the use[of the preferred foot for voluntary motor movements[6].Although many studies have been conducted for many years on preferential use of right or left leg to perform daily operations, the mechanism has not yet been fully clarified[7,8]. Though there are various studies that attribute right- and left-hemisphere dominance to the position of the baby in the womb and to hormonal systems, the generally accepted view is that lateral dominance is a genetic predisposition. Overall, 75-90% of the population is right-handed while the rest is left-handed or ambidextrous[9]. Arm and leg preference is generally reported to be related to cerebral dominance[10].

Cerebral lateralization refers to functional and morphological differences between both hemispheres of the brain[7]. Processes of limb position sense in humans are asymmetrically and predominantly localized in the right hemisphere of the brain[2]. This leads to the speculation that the left side of the body is, in theory, superior to the right side in both hand and leg movements that require the reproduction of a spatial location[11] as it is reported that the left hemisphere is involved in language and motor functions while the right hemisphere is involved in spatial perception and attention. Alternatively, another theory maintains that the left hemisphere controls the direction of extremities and the right hemisphere controls the position and posture of limbs[12]. In both theories, the right hemisphere specialization is dominant in spatial functions such as spatial memory, learning, adaptation and balance. Supporting this theory, the study conducted by Golomer and Mbongo on individuals with a Right Dominant Leg (RDL) and Left Dominant Leg (LDL) in an eyes-closed and open-position setting indicates that both groups apply different balance strategies[5]. They state that individuals with an LDL balance using somatic gravity receptors and proprioceptive feedback localized in the abdomen such as internal organs or kidneys in the body mass centers while those with an RDL balance using the left vestibular predominance[5]. Proprioceptive information from joint receptors, cutaneous receptors and muscle spindles is known to be one of the most important parts of motor control in the maintenance of balance. Proprioceptive information from body movements refers to information from the body such as joint position, muscle strength and spatial orientation[13]. Sensory information from the periphery requires an active neuromuscular system with a sufficient muscle power in order to generate an appropriate motor response to maintain balance[14]. Although there are many studies investigating the relationship between balance and leg strength[15,16,17]no studies have been performed to investigate the relationship between balance and arm and leg strength depending on leg preference.

The purpose of this study is to investigate the effect of arm and leg strength on balance in individuals with a left and right dominant leg.

MATERIAL & METHODS

The study sample consists of 24 healthy male university students (12 right-handersand 12 left-handers) who prefer to use the same arm or leg in manual tasks and have neitherhad any sports-related injuries nor engaged in strength training in the last six months. Screening surveys were conducted to select participants to be invited to the study. Participants were asked questions related to their branches, athletic background, previous injuries, medication history and current engagement in sporting activities. The Waterloo 10-item Footedness Questionnaire-Revised developed by Elias et al. was used in this study to determine lateral preference for footedness[10]. Answers given to the items are scored as follows:-2 for "always left," -1 for "usually left," 1 for "usually right" and 2 for "always right." A total score from -11 to -20 refers to "dominant left foot," a total score from -1 to -10 to "moderately dominant left foot," a total score of 0 to "equal foot use preference," a total score from +1 to +10 to "moderately dominant right foot" and a total score from +11 to +20 to "dominant right foot."Participants with a total score above20 were classified as Right DL while those with a total score below 0 were classified as Left DL. Those with equal foot use preference were not included in the study.

Knee and arm strengths were measured using an isokinetic dynamometer. Knee measurements were performed using an IsoMed device. Arm strength values were measured using a CSM Human Norm device. Static and balance measurements were conducted using a KAT 4000. Measurements were made on different days with 1-week intervals. Data were analyzed at significance levels of 0.05 and 0.01 using the Statistical Package for Social Sciences (SPSS), version 20.

Isokinetic Knee Strength Measurements Isokinetic Measurements were performed at the Department of Physical Therapy and Rehabilitation of the Faculty of Medicine of Afyon Kocatepe University and at the Korel Hotel Clinical Center Unit. Measurements were made using an isokinetic dynamometer (IsoMed, Humac Norm Testing 8 Rehabilitation System, CSMI Medical Solutions, Massachusetts, USA). Participants were allowed to warm up for 5 to 7 min before the test. After the warm-up, gender and age, and body length and body weight values were recorded on a computer to determine the range of motion, and the dynamometer was adjusted for each participant before the test. The joint range of motion was set to 90º. First, participants performed 3 trials on both legs at 60º/s^{-1} to get used to the device and to warm up, and then performed 5 maximal repetitions. They also performed 3 trials on both legs at 180º/s^{-1} followed by 5 maximal repetitions. Quadriceps and hamstring peak torque (PT) (Nm) ratios were determined as a result of the test. The same measurements were used in the supination joint. Participants were allowed a rest period of 20 s between each set of 5 repetitions at 30º/s^{-1} and 120º/s^{-1} to measure supination and pronation values on right and left arm. Supination and pronation peak torque ratios were determined. Measurement results were saved and given to participants as printout.

Balance measurements were performed at the Department of Physical Therapy and Rehabilitation of the Faculty of Medicine of Afyon Kocatepe University.

Static and dynamic measurements were conducted using a Kinesthetic Ability Training 4000 device. Measurements were carried out as a "blind test" for both feet. When the participant said he or she was ready, the set time (30 sec) was started.

Participants were asked to keep the X mark on the computer at the same center. Measurements were recorded as left-right, front-back values and left/right ratio values, front/back ratio values and overall score. Distance from the center 0 as X (right-left) and Y (front-back) and pressure values were recorded in kgf.Body sway motions were plotted as a result of the test within the specified time. Displacements of the center of gravity in the right-left and front-rear directions, the size of the gravity field, body-sway velocities and total displacement distance of the gravity center can be evaluated using this graph[18]. Many techniques have been used for standing balance measurements. Standing on a single foot or both feet is the most commonly used and naturally the easiest position for standing balance measurements. The most commonly used time period on the platform ranges from 20 to 30 s.

Statistical analysis: Data were analyzed using SPSS, version 18.0. Pearson correlation analysis was used to determine the relationship between balance and strength parameters. A significance level of $P \leq 0.05$ was used for all statistical analyses.

RESULTS

The research group is made average of age 22.43 (year), average of height 176.26 (cm) and average of weight 75.56 (kg)

Table 1.Relationship Between Arm Strength And Balance in Right-Handers

		Pro 30^0 Right	Pro 30^0 left	Spu 30^0 right	Spu 30^0 Left	Pro 120^0 right	Pro 120^0 left	Spu 120^0 Right	Spu 120^0 left
SB left	r	.437	.322	.722**	.313	.551*	.437	.475	.375
SB right	r	.253	.036	.301	-.364	.115	.122	.426	.041
DB left	r	.403	.156	.548*	.058	.359	.224	.525	.200
DB right	r	.307	.262	.239	.320	.282	.352	.287	.624*

Pro: Pronation, Spu: Spunation, SB: static balance, DB: dynamic balance, *: p<0.05, **:p<0.01

Table 1 shows that there is a moderate positive correlation between support leg static balance and 30°/s^{-1}supination strength (r= 0.722, p<0.05) and right arm 120°/s^{-1} supination strength (r=0.551, p<0.05) in right-handers. Similarly, there is a moderate positive correlation between support leg dynamic balance and right arm $30^{\circ}/s^{-1}$ strength ($r=0.548$, $p<0.05$) and a moderate positive correlation between dominant leg dynamic balance and left arm $120^{\circ}/s^{-1}$ strength ($r=0.624$, $p<0.05$) in right-handers.

Table 2: Relationship Between Leg Strength And Balance in Right-Handers

		Hams 180^0 Right	Quad 180^0 right	Hams 180^0 left	Quad 180^0 left	Hams 60^0 right	Quad 60^0 right	Hams 60^0 left	Quad 60^0 left
SB left	r	-.186	-.281	-.203	-.342	.359	.322	.359	.081
SB right	r	-.160	-.513	.015	-.482	.078	-.416	-.012	-.178
DB left	r	-.370	-.375	-.183	-.440	.143	.007	.206	.053
DB right	r	-.087	-.201	.041	-.274	.435	-.061	.444	.100

Hams= Hamstring Quad = Quadriceps,SB: static balance, DB: dynamic balance, *: $p<0.05$, **:$p<0.01$

Table 2 outlines that there is no statistically significant relationship between bilateral balance and leg strength in participants with an RDL.

Table 3: Relationship Between Arm Strength And Balance in Left-Handers

		Pro 30^0 Right	Pro 30^0 left	Spu 30^0 right	Spu 30^0 left	Pro 120^0 right	Pro 120^0 left	Spu 120^0 Right	Spu 120^0 Left
SB left	r	.238	.310	.751	.058	.113	.639	.500	.339
SB right	r	-.359	-.596	-.773*	-.532	-.148	-.690	-.832*	-.661
DB left	r	.020	-.126	.468	-.333	.124	.451	.344	.055
DB right	r	.069	-.264	-.272	-.042	.551	.054	-.314	.000

Pro: Pronation, Spu: Spunation, SB: static balance, DB: dynamic balance, *: $p<0.05$, **:$p<0.01$

Table 3 shows that there is highly negative correlation between static balance and non-dominant arm $30^{\circ}/s^{-1}$supination strength ($r= -0.773$ $p>0.05$)and $120^{\circ}/s^{-1}$ supination isokinetic strength ($r=-0.832$, $p>0.05$) in balance legs of participants with an LDL.

Table 4.Relationship Between Leg Strength and Balance in Left-Handers

		Hams 180^0 Right	Quad 180^0 right	Hams 180^0 Left	Quad 180^0 Left	Hams 60^0 right	Quad 60^0 Right	Hams 60^0 left	Quad 60^0 Left
SB left	r	.060	.719	.098	.572	.349	.434	.671	.324
SB right	r	-.290	-.561	-.423	-.667	-.374	-.289	-.650	-.495
DB left	r	-.417	.407	-.114	.203	.008	-.366	.396	-.101
DB right	r	-.301	-.002	-.272	.005	-.459	-.026	-.612	-.034

Hams:Hamstring,Quad:Quadriceps,SB: static balance, DB:dynamic balance, *: $p<0.05$, **:$p<0.01$

Table 4 shows that there is no statistically significant relationship between bilateral balance and leg strength of participants with an LDL.

DISCUSSION

Results show that there is highly negative and statistically significant relationship between static balance and non-dominant arm 30°/s supination and 120°/s supination isokinetic strength in balance legs of participants with an LDL. There is also no statistically significant relationship between lower leg strength and balance.

There are several studies conducted to determine the relationship between lower leg strength and balance ability. However, this study is the first to investigate the relationship between balance and both lower leg strength and arm strength classified based on foot preference. In parallel with this study,[16] were unable to identify any statistically significant relationship between isokinetic lower leg strength and static and dynamic balance in middle-aged adults. Similarly,[15] failed to find a statistically significant relationship between isokinetic strength and balance ability in adolescents. Contrary to this study, reported a moderately positive relationship between non-dominant balance ability and non-dominant leg isokinetic extensor strength and dynamic strength (active jump) balance in both elite and university soccer players[19]. Similarly, found a moderately positive relationship between static and dynamic balance and isometric muscle strength in osteoporotic women between the ages of 65 and 75 [20]. The inconsistency between studies may be due to differences in balance measurement methods and research designs. Based on the results, it can be stated that balance ability and lower leg strength are different neuromuscular capacities.

The most important finding of this study is the high correlation between supination and pronation strength in individuals with an LDL, which was not observed in individuals with an RDL, suggesting that left-handers and right-handers develop different balance strategies. The number of studies on the relationship between laterality and balance is limited.

Golomer and Mbongo examined the relationship between lateral preference and balance control on 13 healthy women (7 RDL and 6 LDL) subjected to a single-leg balance test on a strength platform in three visual conditions (normal vision, left eye closed and right eye closed). Pressure deviations were recorded while balancing on the left leg and on the right leg. In line with the findings of this study, they reported that individuals with an LDL and RDL use different balance control strategies. Whatever the visual conditions, participants with an LDL balanced by displacing the center of pressure towards the supporting foot while those with an RDL balanced by shifting the center of pressure to the right on either left or right foot. They found that LDL and RDL individuals regulate postural control differently, which is accounted for by the fact that right-footed individuals receive information from ear and head receptors while left-footed individuals balance by receiving feedback from abdominal viscera and extremities[5].

These results suggest that hemispheric differences as well as proprioceptive feedback richness may lead to a higher balance in left-footed individuals. It is well known that the right hemisphere is specialized in spatial perception and the left hemisphere is specialized in speech and language learning[12]. Many studies have shown that right-handers' language learning skills are more developed due to left hemisphere specialization[21,12]. The theory claiming that right-handers make more use of ear receptors for balance control than do left-handersis corroborated by the fact that the former have a more developed left hemisphere than the latter. In another study,[22] investigated whether static and dynamic balances of elite soccer players differ according to their leg preferences and reported that left-footers have higher balance ability than right-footers.[23] found a high correlation between kicking accuracy and balance ability, which indirectly supports the findings of this study. Carey et al. carried out a study on 16 teams (236 players) in the World Cup held in France in 1998 to investigate football players' leg preference. They found that left-footers (170 players) had higher kicking accuracy (46.1%) than right-footers (66 players), which supports the idea that left-footers are better able to take advantage of the receptors on the extremities to balance than right-footers and thus develop different balance strategies from them[24]. This explains the relationship between balance and supination and pronation strength in left-footers.

CONCLUSION

In conclusion, this supports the notion that left-footers benefit more from arm movement and strength to control balance than do right-footers. Further studies need to be performed to establish insights into this phenomenon.

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