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The Relationship between Knee and Ankle Proprioception and Anthropometric Indices in Elementary School Children

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Abstract

Background: Knee and ankle joint proprioception plays an important role in balance. Balance can also be influenced by non-environmental conditions such as anthropometric dimensions. The aim of the present study was to investigate the relationship between knee and ankle proprioception and anthropometric indicators in elementary school children.

Methods: The present study is a semi-experimental research in correlational design. The statistical population of this research included all male students in the second to fifth grades of elementary schools, in north of Marand city, 160 of whom met the conditions to enter the research. Anthropometric dimensions were measured by calipers and scanners along with a tape measure; and photography was used for the accuracy of proprioception in ankle and knee joints (ICC ≤0.97). Data analysis was done by Pearson correlation test. All statistical calculations were done at a significance level of p≤0.05.

Results: Knee joint proprioceptive sense was negatively correlated with the length difference between thumb and third toe (r=-0.240, p=0.030), and with the second and third toe length difference (p=0.022 r=-0.253). Also there was a significant negative correlation between ankle joint proprioception sense and foot width (r=0.363, p=0.001), ankle circumference (r=-0.240, p=0.030) and hip circumference (r=-0.242, p=0.02).

Conclusion: The anthropometric dimensions that are subject to heredity and are least affected by the environment, are effective for developable and changeable functions such as proprioception sense.

Key Words: Anthropometric Dimensions, Elementary School Children, Proprioception Sense.

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1- INTRODUCTION

Performing daily activities and sports requires postural control, which is known as the ability of monitoring body position and alignment in space and includes multi-dimensional analysis of the musculoskeletal and nervous systems (1). One of the basic requirements for postural control in motor systems is sensory inputs, hence reducing the feedback of neural afferents can disturb the balance. Disturbance in balance can lead to an increase in the risk of injury during sports activities (2). There are many factors that reduce the incidence of such injuries, one of these factors is having stability, balance and posture control; and one of the most important factors affecting this factor is having a good sense of proprioception (1). The sense of proprioception, which is known as joint sense, makes a person aware of the movement of the joint and the position of the joint, and ultimately causes the regulation of muscle contraction in order to move the joint and strengthen it (2). Also, the control system of the body position in space, which is affected by the proprioceptive sense of the joints, has always attracted the attention of researchers and many researches have been carried out in this regard, and the results have shown that bodily, visual and vestibular sensory messages cause correct balance and maintain proper body alignment (1). Posture is defined as a combination of the position of different joints relative to each other at the same time. The position of each joint will affect the position of other joints. Correct posture is a position in which the least pressure is applied to the joints and muscle activity is at its lowest.

Among the joints, ankle and knee joint injuries, especially complications such as sprains and strains in these joints, are more common (3). The joint, along with the surrounding soft tissues and ligaments, determine the movement and strength of the wrist. The accuracy of proprioception, especially in the ankle and knee joints, is very important in maintaining the proper function of the joint during daily activities, sports, and movement skills (4).

Various neurophysiological and mechanical factors can affect balance. Features such as height, weight, body composition, support surface, distance from the center of gravity to the ground, length and weight of each organ, arm length, muscle torque, and mass distribution in different parts of the body can mechanically affect the balance affected by the proprioception of people's joints. (5). Many studies have been conducted on the relationship between anthropometric and physiological parameters and balance in athletes and non-athletes during the last three decades (6). For example, Moin et al. investigated the relationship between some anthropometric characteristics and static and dynamic balance of inactive female students. The research results showed that there is a weak inverse correlation between leg length and dynamic balance and a weak direct correlation between body mass index and dynamic balance (7).

In another study, Berenjian et al. compared static and dynamic balance; and investigated the relationship between balance and anthropometric indicators in selected sports. The results showed a significant relationship between anthropometric indicators (thigh circumference, hip, thigh and leg circumference, body fat, and body mass index) and dynamic balance, which is influenced by proprioception sense (8). Ayers et al. investigated the relationship between balance and foot position and foot size in physical education students. The results of this study showed a weak negative correlation between static balance and foot position, a weak negative correlation between dynamic balance and leg length, and a weak positive correlation

between static balance and heel width (9). The relationship between some anthropometric parameters and balance at different modes was investigated and the results showed that there is a significant relationship between leg length, heel width, big toe width and balance only in standing position on two legs. There is no significant relationship between static balance and anthropometric parameters during standing on one leg (10). Reviewing the literature, we found that most of the previous studies had examined the relationship between balance and anthropometric dimensions in adults and no study has studied the relationship between anthropometric characteristics and sense of proprioception in children. Therefore, the present study aimed to investigate the relationship between knee and ankle proprioception sense with anthropometric indicators in elementary school children.

2- MATERIALS AND METHODS

This study was a semi-experimental research in correlational design. It has been approved by the Research Ethics Committee of University of Mohaghegh Ardabili under the ethics code of IR.UMA.REC.1401.067. The statistical population of this study included all male students in the second to fifth grades of Shahid Farrokhi elementary School in Marand city (300 students), of which 160 individuals found the conditions to enter the research.

The criteria to enter in the research included not having musculoskeletal abnormalities, movement limitations, mental and nervous diseases, and metabolic diseases. The criterion to exclude the research was non-cooperation in the implementation of the research by him or his parents.

In order to collect information, after obtaining the necessary permits from the General Department of Education in Marand, the researchers went to the school to coordinate with the principal and school officials for the implementation of the project. The students' parents signed statements of informed consent following a full explanation regarding the nature of the experiment. The participants were asked to be present in the school gym at a given time. The anthropometric indices of each subject including foot width, foot length, toes difference, fingers difference, palm width, palm length, ankle circumference, wrist circumference, neck circumference, hip circumference, abdominal circumference, and Waist to Hip Ratio (WHR) were measured by ruler and tape measure. In the next step, the photographic method (ICC $\leq$0.97) was used to measure the accuracy of proprioception sense in the ankle and knee joints. For this purpose, after skin marking on the outer side of the limb, each subject sat on a chair and placed his legs in a hanging position. Then, the subject was asked to move the testing joint to the target angle with his eyes open, and in this situation, the first photo was taken from the external side of the joint. After that, to eliminate visual interference, a blindfold was used during the measurement and the participant was asked to reconstruct the target angle. This measurement was repeated three times and with each repetition, a photograph of the reconstructed angle was taken so that the average of these three angles was recorded as the record of the subject in the reconstruction of the target angle. Finally, all the recorded images were analyzed by Auto CAD 2014 software, and the amount of difference between the reconstructed angle and the target angle (open eye condition), was recorded as the error angle (absolute error), regardless of whether the movement direction was positive or negative. In the ankle joint, a 10-degree dorsiflexion angle and in the knee joint, a 45-degree flexion angle were used as the target angles. In data analysis, after testing

the normality of the data distribution with Shapirowilk test, Pearson correlation coefficient test was used to check the correlation of the variables. All statistical calculations were done by SPSS version 21 software at a significance level of 5%.

3- RESULTS

Table 1 shows the demographic characteristics of the examined students. Correlations between proprioception sense of knee joint and some anthropometric indices have been reported in **Table 2**.

Table-1: Demographic characteristics of boy students aged 9-11 in Marand city

Variables	Mean	Standard deviation
height	142.18	8.53
weight	39.91	10.2
age	9.92	1.15

Table-2: Correlations between proprioception of knee joint and some anthropometric indices in male students aged 9-11 in Marand city

Variables		Correlation coefficient (r)	Significance level (P)
Knee proprioception	foot width	-0.071	0.527
	foot length	-0.171	0.125
	difference in the length of thumb and second toe	-0.068	0.542
	difference in the length of thumb and third toe	-0.240	*0.030
	difference in the length of second and third toes	-0.253	*0.022
	difference in the length of middle finger and index finger of the hand	-0.247	*0.025
	difference in the length of middle and second finger of the hand	-0.001	0.991
	difference in the length of second finger and index finger of the hand	-0.082	0.469
	Palm width	0.195	0.080
	Palm length	-0.261	*0.018
	Ankle circumference	0.022	0.841
	wrist circumference	0.040	0.720
	neck circumference	-0.031	0.780
	hip circumference	-0.025	0.822
	Abdominal circumference	0.026	0.820
	WHR	0.122	0.276

* indicates the significance of the correlation coefficient.

There was a significant negative correlation between knee proprioception and difference in the length of thumb and third toe (p=0.030, r=-0.240), difference in the length of second and third toe (p=0.022, r=-0.253), difference in the length of middle finger and index finger

(r=-0.247, p=0.025), and palm length (p=0.018, r=-0.261).

Significant negative correlations were also observed between ankle proprioception and foot width (r=-0.363, p=0.001), palm width (p=0.035, r=-0.234), ankle circumference (r=-0.240, p=0.030) and hip circumference (r=-0.242, p=0.028) (**Table 3**).

Table-3: Correlations between ankle proprioception and some anthropometric indices in male students aged 9-11 in Marand city

Variables		Correlation coefficient (r)	Significance level (P)
Ankle proprioception	foot width	-0.363	*0.001
	foot length	-0.115	0.302
	difference in the length of big and second toe	0.075	0.501
	difference in the length of thumb and third toe	-0.040	0.720
	difference in the length of second and third toes	-0.008	0.945
	difference in the length of middle and index finger of the hand	-0.116	0.299
	difference in the length of middle and second finger of the hand	-0.024	0.828
	difference in the length of second and index finger of the hand	-0.063	0.580
	Palm width	-0.234	*0.035
	Palm length	0.108	0.333
	ankle circumference	-0.240	*0.030
	wrist circumference	-0.162	0.146
	neck circumference	-0.211	0.058
	hip circumference	-0.242	*0.028
	Abdominal circumference	-0.151	0.177
	WHR	-0.045	0.688

* indicates the significance of the correlation coefficient.

4- DISCUSSION

Results of the present study showed that there was a significant negative correlation between knee proprioception and the difference between the length of thumb and third toe, the difference between the length of second and third toe, the difference between the length of middle and index finger, and palm length. There was also a significant negative correlation between ankle proprioception and foot width, palm width, ankle circumference and hip circumference.

We found no article published on anthropometric dimensions in correlation to knee and ankle proprioception in children; however, many studies have been conducted on factors that affect balance. Balance is defined as the ability to maintain the body's center of mass within the base of support. The balance is maintained through the movement of body weight in different directions with safety,

speed (response time), and coordination. Balance is dynamic and requires constant adjustments to adapt to external perturbations, through the use of vision, muscle activity, articular positioning and proprioception, and the vestibular system, all acting in concert (11). It has been shown that age, height, weight, foot shape, body composition, and level of activity, and health can affect balance ability (12). Jeronymo et al. (2020) investigated the relationship between postural stability, anthropometry measurements, body composition, and sport experience in judokas with visual impairment and announced that postural instability was correlated with anthropometric measurements, mainly body fat and height, and judo experience (13). It has been also reported that variation in the leg length and foot length positively correlates with posture, thus indirectly influencing on balance. Multiple studies on various populations have demonstrated that an increase in body mass can change the antero-posterior position of the center of gravity. Likewise, an individual limb length can alter the vertical height of the center of gravity, whereas the foot length determines the flexibility of the center of gravity and, therefore, influences postural stability (14).

Another study that was performed on 206 men and women over 50 years old, reported that increased body mass can increase the likelihood of people falling during walking (15). Since the increase in weight causes a decrease in the speed of movement of the center of gravity in the legs and a decrease in the range of stability (16). Moreover, the relationship between the subjects' height and their postural stability was found to be significant and positive (17). In such a way, the increase in height increases the fluctuations of the subject's center of gravity that is due to the favorable position of proprioception in knee and ankle joints. However, some researchers have found opposite results (18-20).

Joint proprioception is actually a tool to report the state of the joint in the body to the central and peripheral nervous system (21). Based on numerous studies, proprioceptive sensation of joints is affected by several indicators (22). One of these indicators is the anthropometric dimensions of the body. For example, the more and more complete the range of motion in the joints, the more neural feedback from the positions in the joint to the central nervous system (23). The range of motion of joints will be different based on the body's center of gravity, which itself is subject to anthropometric factors (23).

According to the findings of the present study, it was revealed that the smaller the difference in the length of thumb and middle toes, and the difference in the length of second and middle toes, the better knee proprioception; thus, it might be said that these differences in the toes reduce the level of support in the soles of the feet during running and walking, and the muscles supporting the knee become more active to maintain the body structure to compensate for the limited range of motion of the ankle (23). Moreover, knee proprioception was inversely correlated with the length difference between middle and index finger; and with the length of palm which are due to the anthropometric relationships of all bone organs, affecting the center of gravity and, indirectly, the proprioceptive sense of the knee joint (24).

The significant negative correlation between ankle proprioception and sole width, ankle circumference and hip circumference can indicate that the lower the range of motion of the ankle and other joints that are related and close to it, the lower the proprioception of that joint. It is plausible that the increase in the length and width of the feet increases the base of the support area and thus provides a wider

area for the center of gravity to restore balance during instability (24).

The ankle area, in addition to its bony components, is made up of connective tissues that are changeable based on environmental and hereditary factors; and big dimensions of the connective tissues create movement restrictions for the joint and ultimately reduce the sense of proprioception. The significant negative correlation between ankle joint proprioception and palm width might be due to the anthropometric relationship of all bony organs, especially foot dimensions, which affects the center of gravity and indirectly affects the ankle joint proprioception.

5- CONCLUSION

According to the results obtained in this study, the anthropometric dimensions that are a function of heredity, and not much affected by the environment, are effective on the developable and changeable functions such as proprioception sense of joints.

6- CONFLICT OF INTEREST

None

7- FUNDING

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9- REFERENCES

1. Shumway-Cook A, Woollacott MH. Motor control: Translating research into clinical practice. Philadelphia: Lippincott Williams & Wilkins; 2007.

2. Wikstrom EA, Powers ME, Tillman MD. Dynamic stabilization time after isokinetic and functional fatigue. Journal of Athletic Training. 2004; 39(3):247-53.

3. Hertel JN, Guskiewicz KM, Kahler DM, Perrin DH. Effect of lateral ankle joint anesthesia on center of balance, postural sway and joint position sense. J Sport Rehab 1996; 2: 111-119.

4. Lephart SM, Pincivero DM, Rozzi SL. Proprioception of the ankle and knee. Sports Med 1998; 25(3): 149-0155.

5. Palmieri RM, Ingersoll CD, Cordova ML, Kinzey SJ, Stone MB, Krause BA. The effect of a simulated knee joint effusion on postural control in healthy subjects. Archives of Physical Medicine and Rehabilitation. 2003; 84(7):1076-9.

6. Hobbs ML. Dynamic balance and basketball playing ability [MSc. thesis]. San Marcos, Texas: Texas State University; 2008.

7. Moein E, Movaseghi F. Relationship between some anthropometric indices with dynamic and static balance in sedentery female college students. Turkish Journal of Sport and Exercise. 2016; 18(1):45-9.

8. Berenjian Tabrizi H, Abbasi A, Jahadian H. [Comparing the static and dynamic balance and their relationship with the anthropometric characteristics in athletes of selected sports (Persian)]. Sport Sciences Quarterly. 2014; 6(14):33-46.

9. Irez GB. The relationship with balance, foot posture, and foot size in school of physical education and sports students. Educational Research and Reviews. 2014; 9(16):551-4.

10. Sakamitsu T, Urabe Y, Yamamoto T. Relationship of kyphosis with balance and walking ability in the elderly. Journal of Exercise Physiology. 2007; 22(4):489-94.

11. Mocanu GD, Murariu G, Potop V. Optimization of body balance indices according to Body Mass Index categories during physical education lessons for university students. Pedagogy of Physical Culture and Sports. 2022; 26(4):233-4.

12. Fateme H. Abdolahi, Ali S. Variani, Sakineh Varmazyar. Predicting Ability of Dynamic Balance in Construction Workers Based on Demographic Information and Anthropometric Dimensions. Safety and Health at Work. 2021; 12(4): 511-516**.**

13. Jeronymo BF, Silva PRDO, Mainenti M, Felicio LR, Ferreira AdS, Carvalho TLd, Vigário P. The Relationship between Postural Stability, Anthropometry Measurements, Body Composition, and Sport Experience in Judokas with Visual Impairment. Asian J Sports Med. 2020; 11(3):e103030.

14. Arora M. Prediction of Stature by the Measurement of Lower Limb Length and Foot Length. Int J Med Res Prof. 2016; 2(2); 303-05.

15. Fjeldstad C, Fjeldstad AS, Acree LS, Nickel KJ, Gardner AW. The influence of obesity on falls and quality of life. Dyn Med. 2008; 7:4.

16. Hue O, Simoneau M, Marcotte J, Berrigan Fl, Dore J, Marceau P, Marceau S, Tremblay A, Teasdale N. Body weight is a strong predictor of postural stability. Gait Posture. 2007; 26(1): 32-38.

17. Beyranvand R, Sahebozamani M, Daneshjoo A. The Relationship of Anthropometric Factors with Postural Stability and Ankle/hip Range of Motion in the Elderly. J Mazandaran Univ Med Sci 2017; 27 (147):171-182.

18. Greve JM, Cuğ M, Dülgeroğlu D, Brech GC, Alonso AC. Relationship between anthropometric factors, gender, and balance under unstable conditions in young adults. Biomed Res Int. 2013; 2013:850424.

19. Baharloei H, Moghadam N. Correlation between Body Mass Index and postural balance in elderly. Journal of Rehabilitation. 2012; 12:54-59.

20. Berenjeian Tabrizi H, Abbasi A, Jahadian H. Comparison of Static and Dynamic Balance and Their Relationship with Anthropometric Characteristics in Selected Athletes. Sport Sciences Research Quarterly. 2014; 6(14):33-46.

21. Chou LW, Hou SL, Lee HM, Fregni F, Yen A, Chen V, Wei SH, Kao CL. Effects of Noise Electrical Stimulation on Proprioception, Force Control, and Corticomuscular Functional Connectivity. IEEE Trans Neural Syst Rehabil Eng. 2023; 31:2518-2524.

22. Chen X, Qu X. Age-Related Differences in the Relationships between Lower-Limb Joint Proprioception and Postural Balance. Hum Factors. 2019; 61(5):702-711.

23. Jerosch, J., Prymka, M. Proprioception and joint stability. Knee Surg, Sports traumatol, Arthroscopy 1996; **4**:171–179.

24. Pitchai P, Gurav R, Chauhan SK. Association between Anthropometric Factors and Balance among Elderly Fallers and Non-Fallers: A Cross-Sectional Study. The Internet Journal of Allied Health Sciences and Practice. 2021; 19 (3), Article 7.