ORİJİNAL ARAŞTIRMA ORIGINAL RESEARCH
DOI: 10.5336/sportsci.2022-93487

The Relationship of Speed and Agility Performance with Speed of Linear Direction Change in Handball Players with Hearing Disabilities: Experimental Research

İşitme Engelli Hentbolcularda Sürat, Çeviklik ve Linear Yön Değiştirme Hızı Arasındaki İlişki: Deneysel Araştırma

Serdar ELER[a], Nebahat ELER[b], Pelin AKSEN CENGİZHAN[c], Marko JOKSIMOVIC[d]

[a]Department of Trainer Education, Gazi University Faculty of Sport Sciences, Ankara, Türkiye
[b]Department of Trainer Education, Zonguldak Bülent Ecevit University Vocational School of Physical Education and Sports, Zonguldak, Türkiye
[c]Department of Trainer Education, Kırıkkale University Faculty of Sport Sciences, Kırıkkale, Türkiye
[d]Department of Physical Education, University of Montenegro Faculty of Sport and Physical Education, Niksic, Montenegro

This study was presented as an oral presentation at 16th International Sport Sciences Congress, October 31-November 3, 2018, Antalya, Türkiye.

ABSTRACT Objective: Handball is a type of sport, in which speed and agility are important, and it involves continuous explosive sprints, jumps, direction changes, giving passes, and body contact while doing these. This study aimed to analyze the relationship between body compositions, speed, agility performance, and speed of linear-direction change in handball players with hearing disabilities. **Material and Methods:** A total of 20 athletes who were members of the Turkish National Male Handball Team with hearing disabilities participated in the study. The participants' average age, height, and body weight were 27.00±1.40 years, 180.30±1.50 cm, and 82.50±2.03 kg, respectively. The body compositions of the athletes were evaluated with a BIA analyzer (Tanita BC-418, Tanita Corporation, Tokyo-Japonya). Linear change of direction (Change of Direction and Acceleration Test), agility (Pro-Agility Test) and 20 m sprint tests were evaluated with a Photocell-connected Smartspeed (Fusion Sport, Australia) mat device. The correlation coefficients of the variables and their statistical differences were calculated with the Pearson correlation test. **Results:** There was a positive correlation between body fat percentages and the speed of direction change (r=0.490, p<0.05). There is a positive correlation between speed and agility (r=0.674, p<0.01) and also between the speed of linear change of direction (r=0.692, p<0.05). **Conclusion:** In this study, a positive correlation was found between linear chance of direction and body fat percentage, speed, linear chance of direction and agility in hearing impaired athletes. Studies on change of direction, speed, agility and other physical fitness parameters are extremely limited. To improve the performance of athletes with hearing disabilities, it is also necessary to examine other physical components. We consider that the study will contribute to this field.

Keywords: Hearing disabilities; handball; linear direction change; agility; speed

ÖZET Amaç: Hentbol, hız ve çevikliğin önemli olduğu bir spor türüdür ve bunları yaparken sürekli patlayıcı sprintler, sıçramalar, yön değişiklikleri, pas verme ve vücut teması içerir. Bu çalışmanın amacı, işitme engelli hentbol oyuncularında vücut kompozisyonları, hız, çeviklik performansı ve lineer yön değiştirme hızı arasındaki ilişkiyi incelemektir. **Gereç ve Yöntemler:** Çalışmaya Türkiye A Milli Erkek Hentbol Takımında yer alan işitme engelli toplam 20 sporcu katılmıştır. Sporcuların ortalama yaş, boy ve vücut ağırlığı sırasıyla 27,00±1,40 yıl, 180,30±1,50 cm ve 82,50±2,03 kg'dır. Sporcuların vücut kompozisyonları Tanita (BC-418) vücut analiz cihazı ile değerlendirildi. Lineer yön değişimleri (Yön Değiştirme ve Hızlanma Testi), çeviklik (Pro Çeviklik Testi) ve 20 m hız değerleri Fusion Sport cihazı ile analiz edildi. Değişkenlerin korelasyon katsayıları ve istatistiksel farklılıkları Pearson korelasyon testi ile hesaplandı. **Bulgular:** Vücut yağ yüzdeleri ile yön değiştirme hızı arasında pozitif bir ilişki vardı (r=0,490, p<0,05). Hız ile çeviklik arasında (r=0,674, p<0,01) ve ayrıca doğrusal yön değiştirme hızı (r=0,692, p<0,05) arasında pozitif bir ilişki vardır. **Sonuç:** Yapılan bu çalışmada, işitme engelli sporcularda vücut yağ yüzdesi ile yön değiştirme hızı arasında pozitif; hız ile çeviklik arasında ve ayrıca hız ile doğrusal yön değiştirme hızı arasında pozitif bir ilişki vardır. İşitme engelli sporcularda yön değiştirme, hız, çeviklik ve diğer fiziksel uygunluk parametreleri üzerine yapılan çalışmalar son derece sınırlıdır. İşitme engelli sporcuların spor performanslarını artırmak için diğer fiziksel bileşenlerin de incelendiği, daha ileri çalışmalara ihtiyaç duyulmaktadır. Bu çalışmanın alana katkı sağlayacağını düşünüyoruz.

Anahtar Kelimeler: İşitme engelliler; hentbol; lineer yön değiştirme; çeviklik; hız

Correspondence: Nebahat ELER
Department of Trainer Education, Zonguldak Bülent Ecevit University Vocational School of Physical Education and Sports, Zonguldak, Türkiye
E-mail: nebahateler@gmail.com

Peer review under responsibility of Turkiye Klinikleri Journal of Sports Sciences.

Received: 21 Sep 2022 ***Received in revised form:*** 21 Dec 2022 ***Accepted:*** 23 Dec 2022 ***Available online:*** 29 Dec 2022

Many remarkable attempts have been made in recent years to prevent disabled individuals from staying away from society and maintaining an isolated life. One of the most effective and important ways is sports events, adapted exclusively for these individuals. Hearing-impaired athletes do not experience any physical deprivation and can participate in competitive sports without any restrictions. Hearing-related communication barriers are the only factors that distinguish them from other athletes.[1] Sports activities are encouraged for the disabled primarily to reveal their desire to become self-sufficient individuals adapting to society.[2] People with hearing disabilities often prefer to live in their environment, and since they prefer to communicate with each other in sign language. But other people in society generally have no information about sign language, they avoid interacting, which causes them to isolate themselves from society.[3] Therefore, they avoid participating in sports activities with able-bodied athletes. Sports organizations encourage the disabled to develop normally and to meet with other disabled individuals to fulfill an extremely important social function. Participation in sports helps the disabled become social individuals.[4]

Hearing impairment is affected by many factors, such as degree, type, and levels, such as the child's intelligence, skills of language, and level of education. Hearing impairment that is either congenital or occurring before the development of language skills will seriously prevent the individual from acquiring speaking skills.[5] Delays in basic motor skills in hearing-impaired individuals, and also the lack of regular and coordinated muscle activities due to their inability to receive auditory stimuli can be considered among the causes of muscle strength weakness in hearing-impaired individuals. The vestibular system is very important for the postural mechanism and muscle control. The problems in this in hearing-impaired individuals also adversely affect motor functions and muscle strength, and compared to the normal group, it has been shown that, on average, individuals with hearing impairments attain poorer motor development and physical fitness performance.[6,7] Hearing-impaired children have poorer agility and balance compared to other children.[8]

Akınoğlu and Kocahan examined the effects of hearing impairment on physical fitness parameters in hearing-impaired athletes and reached the following results: hamstring/quadriceps isokinetic muscle strength ratio between 53% and 54%; dominant/non-dominant side ratio below 5% for all athletes; low endurance of the posterior and anterior core muscles in male athletes; low grasping power in both genders; similar body fat percentage between female athletes with hearing-impairment and that of able-bodied athletes; and lower body fat weight in male hearing-impaired athletes.[9]

Physical fitness capacity is one of the most important features in hearing impairment athletes and there are many studies about physical fitness capacity. These features are; body composition, speed, agility, flexibility, balance, cardio-respiratory resistance, muscle strength reaction time, and physiological and motor performance.[10]

In sports, players need to make sudden changes in body movements and the joints to move quickly, the player's ability to successfully perform these maneuvers depends on visual processing, perception, reaction time, and other factors.[11] Handball is a sport in which speed and agility are important and it includes continuous explosive sprints, giving passes, jumps, direction changes, and body contact while doing these.[12] It is more important to move in different directions than linear sprinting in all sports.[13] In theory, body structure body composition, and dimensions, such as the center of gravity, body fat amount, and length of body segments can affect agility and speed performance. Two athletes of the same body weight, the athlete with high body fat percentage and low muscle mass must produce more force per unit of muscle mass during direction change and acceleration due to high inertial forces.[14]

However, studies on hearing-impaired athletes have mostly focused on the balance activity of the players and little research has been done on other physical components. These individuals need to participate in team sports, interact with team members, and act according to the game context. In the game, the athlete must slow down, accelerate, or change direction by maintaining speed.[7] For the hearing-impaired athletes, the Deaflympics (International Games for the Deaf) (every 4 years), The Deaf World Championships, and the Deaf European Championship have been organized. This study was to investigate the relationship of linear change of direction (COD) times with body composition, speed, and agility performances in the Turkish National Handball Team players, who were the 2017 Deaflympics Champions.

MATERIAL AND METHODS

Participants: Twenty male athletes participated voluntarily in the study (Table 1); Average age (27.00±1.40 years), average height (180.30±1.50 cm), average body weight (82.50±2.03 kg), average sports age (7.35±1.87 years).

All participants were the Turkish National A Handball Team players, who were the 2017 Deaflympics Champions. Athletes were recruited if they were currently active in Türkiye handball (in the hearing-impaired league) competition; had a general field sports training history extending over the previous 12 months, at least 2 training per week; did not have any existing medical conditions that would compromise participation in the study; we're available for all testing occasions. Detailed information about the study was provided to the athletes, an "informed consent form" was filled out and their approval was obtained. The research procedures were carried out in accordance with the human research ethical standards of the 2008 Declaration of Helsinki.

Research Design: A familiarization session was conducted, 48 hours before the first testing session. Two testing sessions were then completed by all subjects, also separated by 48 hours. Before data collection in the first testing session, each subject's age, weight, height, body mass index (BMI), and body fat ratio were recorded. Height measurements of the ath- letes were obtained using a SECA (Seca, Germany) physical distance scale with an accuracy of 0.01 m. BMI and body fat ratio were measured with a BIA analyzer (Tanita BC-418, Tanita Corporation, Tokyo-Japonya). Subjects completed 3 different tests within a session: To athletes; for linear direction change measurement, Change of Direction and Acceleration Test (CODAT), for agility measurement; Pro-Agility Test and 20 m Speed Test were applied for speed measurement (Table 1). Values were evaluated with a Photocell-connected Smartspeed (Fusion Sport, Australia) mat device all tests were conducted in the handball hall at 13:00. 30 minute general warm-up protocol was applied just before tests. The order of the tests completed by the subjects was randomized across the group. The same order was kept constant across the two testing occasions. Two trials were used per test for each subject, the average was taken for each session. Time was measured through the use of timing gates. Rest periods of 5 minutes were allocated between all trials.

Athletes used a standing start for all speed tests, placing their preferred foot in the forward position. If athletes rocked backward, hesitated, or slipped before starting in any of the speed tests, the trial was disregarded and another attempt was allowed after the recovery period. Time for each distance was recorded to the nearest 0.01 s.

TABLE 1: Descriptive statistics of the research group.

	n	Minimum	Maximum	$\bar{X}$	SD
Age (year)	20	19	38	27.00	6.27
Height (cm)	20	168	198	180.30	6.72
Weight (kg)	20	66.50	102.30	82.50	9.07
BMI (kg/m^2)	20	25.01	0.33	22.90	1.49
BM (%)	20	7.00	18.90	12.86	2.80
20 m speed (s)	20	2.81	3.26	3.00	0.12
CODAT (s)	20	4.49	5.82	4.95	0.33
Pro agility (s)	20	4.79	5.70	5.22	0.20

SD: Standard deviation; BMI: Body mass index; CODAT: Change of Direction and Acceleration Test.

20 m SPEED TEST

20 m Speed Test (sec) was applied to measure speed. A sufficient rest period was given to the athletes and ran 20 m at maximum speed with the start sign. Two trials were made, and the best result was recorded.[15]

CODAT

CODAT was applied to measure the linear COD. The dimensions and movement direction for the CODAT are shown in Figure 1. The CODAT involves a straight 5 m sprint, followed by three 3 m sprints. These 3 m sprints are made at angles of 45° and 90°. Following the third 3 m sprint, there is a straight 10 m sprint to the finish line. The athletes were instructed to complete the test as quickly as possible. The athletes were also to ensure they cut around markers and did not run over them. Trials were stopped and reattempted after the rest period if the subject cut over the top of a marker so that two successful trials were completed. Two trials were made, a sufficient rest period was given between trials, and the best result was recorded (Figure 1).[15]

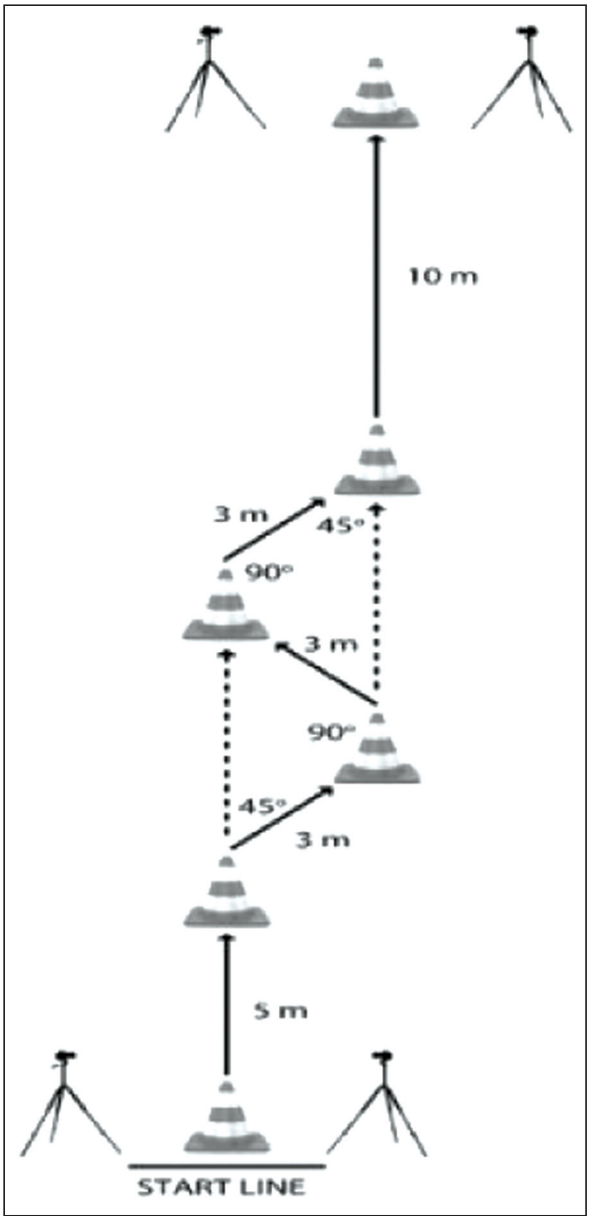

FIGURE 1: Change-of-direction and acceleration test dimensions and completion route.[16]

PRO-AGILITY TEST

The dimensions and movement direction for the Pro-Agility Test are shown in Figure 1. Agility was measured by the Pro-Agility Test. Cones were placed 5 yards (4.57 m) to the left and right of the starting line, the athlete touched the cone on the right, then the cone on the left, and passed the starting line to end the test. Two trials were made, a sufficient rest period between trials was given, and the best result was recorded (Figure 2).[16]

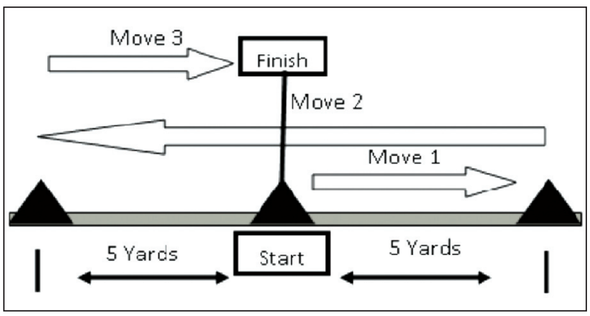

FIGURE 2: Agility Test dimensions and completion route.[16]

STATISTICAL ANALYSIS

Correlation coefficients and statistical significance of the variables were calculated using the Pearson correlation test. The data were analyzed in IBM SPSS package program 20 (America). p values less than 0.01 and 0.05 were considered statistically significant.

RESULTS

According to the results of the statistical analyses, there was a moderate positive correlation between handball players' body fat percentages and linear

TABLE 2: The relationship between handball players' body composition, speed, and agility performances and linear change of direction times.

	Height (cm)	Weight (kg)	BMI (kg/m^2)	BM (%)	20 m speed (s)	CODAT (s)	Pro agility (s)
Height (cm)	1						
Weight (kg)	0.774**						
BMI (kg/m^2)	0.233	0.685**					
BM (%)	-0.011	0.422	0.704**				
20 m speed (s)	0.259	0.278	0.171	0.227			
CODAT (s)	-0.016	0.304	0.419	0.490*	0.674**		
Pro agility (s)	-0.245	0.152	0.331	0.403	0.477*	0.692**	

*Significant correlation at 0.05; **Significant correlation at 0.01; BMI: Body mass index; CODAT: Change of Direction and Acceleration Test.

COD times (r=0.490, p<0.05). A good positive correlation was observed between speed and speed and linear COD (r=0.674, p<0.01) and agility and linear COD times (r=0.692, p<0.05). A low moderate correlation was found between agility and speed (r=0.477, p<0.05). No relation was found between height, body weight, BMI, and linear COD times (Table 2).

DISCUSSION

There was a positive correlation between agility and speed and also between body fat percentages and linear COD times of the Turkish National A hearing-impaired handball players. The results of the previous studies investigating the relationship between body composition, especially body fat percentage and muscle mass, and agility, speed, and COD are contradictory. Aslan et al. reported that there is a relationship between height and 20 m sprint times.[17] Aktaş and Aslan studied amateur footballers and reported a moderate positive correlation between body compositions and sprint values, and also between 10 m and 30 m sprint values and body fat percentage and mass.[18] Chaouachi et al. examined agility in basketball players and reported a strong correlation between the t-test and weight (r=0.58), and between the t-test and body fat percentage (r=0.80).[19] On the other hand, Sheppard and Young studied Rugby players and reported a weak correlation between body fat and speed of running with the COD (r=0.21).[20] Similarly, Mohammad and Tareq, GanjiSaffar et al., and Gioldasis et al. found that there was no significant relationship between body fat percentage and speed, agility, and reaction time.[21-23]

Zemková and Hamar investigated the relationship between agility and reaction and movement times in karate-kumite athletes and found that both the speed of decision-making and the speed of COD contribute to agility performance, albeit each to a different extent.[24] Horička et al. found a very low relationship between the COD time and linear speed in basketball, football, and handball players. Speed and agility are different physical qualities and it has been stated that speed does not increase the speed of direction change.[25] Bayraktar reported that there is a relationship between the linear speed of handball players and the speed of direction change, but it was found that it does not matter in terms of reactive agility performance.[26] Buttifant et al. studied footballers and found that the performance relationship between the 20 m straight sprint test and the COD test (a four-way change of about 20 m) was weak (r=0.33).[27]

Sassi et al. examined the relationship between vertical jump, directional sprint, and agility in male athletes, and found a weak relationship between linear sprint and agility.[28] Little and Williams studied the relationship between acceleration, maximum speed, and agility in professional footballers via the 10 m acceleration test, flying 20 m test (maximum speed), and zig-zag agility test. The results showed that the relationship between acceleration, maximum speed, and agility was low.[29]

Simonek et al. studied the relationships between agility, maximal speed, and acceleration times in football, basketball, volleyball, and handball players and found that there was a low negative correlation between basketball, football, and handball players'

COD and linear speed times. They stated that speed and agility did not increase the speed of direction change.[11] Spaniol et al. hypothesized that there is a relationship between speed of direction change and speed, conducted 40-yard sprint and 20-yard shuttle agility tests, and found that there was a significant relationship between agility and speed.[30] Draper and Lancaster found a significant moderate correlation (r=0.472) between the 20 m sprint performance and the Illinois agility test.[31]

Açak et al. compared the agility and visual response time of futsal players with hearing impairment and found a significant difference between hearing-aid users and those who were deaf (according to disability status determination).[32] This result shows that the agility parameter of the hearing-impaired individuals differs in accordance with the degree of disability. They stated that better physical values of hearing-impaired athletes affect sports performance, and that hearing loss is not an advantage or a disadvantage. Atar et al. studied sedentary hearing-impaired youth under 18 and over 18 and found that there was no significant difference between static balance and agility parameters.[33] Ciğerci et al. compared the Illinois agility test values of athletes and found a significant difference between hearing-impaired sedentary males and able-bodied sedentary males ($p<0.05$).[34] However, they did not find a significant difference between hearing-impaired male volleyball players and those who were able-bodied, and between hearing-impaired sedentary females and those who were able-bodied. These outcomes show that hearing impairment negatively affects some motor features, such as reaction time, hand-grip strength, triple-jump, balance, anaerobic power, and agility. However, when they evaluated the body fat percentage, hand-grip strength, flexibility, anaerobic power, and speed values of the hearing-impaired athletes and those who were able-bodied, they reported that the hearing-impairment is not an obstacle for performing sports. İbrahim et al. administered the t-test, Zigzag, and 505 agility tests in able-bodied young (14.4±0.76 years) and older (16.56±0.88 years) netball players and hearing-impaired young (14.50±0.67 years) and older (16.62±0.67 years) netball players.[7] As a result of the study, lower COD time was observed in young athletes compared to older athletes and in hearing-impaired athletes compared to able-bodied athletes. Maintaining postural stability and balance is a complex process that requires the involvement of multiple systems such as sensory and information processing systems. This complex process negatively affects individuals with problems in terms of COD performance, semicircular canals, and vestibular system.[35]

CONCLUSION

In this study, a positive correlation was found between linear chance of direction and body fat percentage, speed, linear chance of direction and agility in hearing impaired athletes. Studies on COD, speed, agility and other physical fitness parameters are extremely limited. To improve the performance of athletes with hearing disabilities, it is also necessary to examine other physical components. We consider that the study will contribute to this field.

Source of Finance

During this study, no financial or spiritual support was received neither from any pharmaceutical company that has a direct connection with the research subject, nor from a company that provides or produces medical instruments and materials which may negatively affect the evaluation process of this study.

Conflict of Interest

No conflicts of interest between the authors and / or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise, working conditions, share holding and similar situations in any firm.

Authorship Contributions

Idea/Concept: *Serdar Eler;* ***Design:*** *Serdar Eler, Nebahat Eler;* ***Control/Supervision:*** *Serdar Eler, Pelin Aksen Cengizhan;* ***Data Collection and/or Processing:*** *Pelin Aksen Cengizhan, Marko Joksimovic;* ***Analysis and/or Interpretation:*** *Pelin Aksen Cengizhan, Marko Joksimovic;* ***Literature Review:*** *Pelin Aksen Cengizhan, Marko Joksimovic;* ***Writing the Article:*** *Pelin Aksen Cengizhan, Nebahat Eler;* ***Critical Review:*** *Marko Joksimovic, Nebahat Eler;* ***References and Fundings:*** *Serdar Eler, Nebahat Eler;* ***Materials:*** *Serdar Eler, Pelin Aksen Cengizhan, Nebahat Eler.*

REFERENCES

1. Kurková P, Válková H, Scheetz N. Factors impacting participation of European elite deaf athletes in sport. J Sports Sci. 2011;29(6):607-18. [Crossref] [PubMed]
2. Özer DS. Engelliler İçin Beden Eğitimi ve Spor. 1. Baskı. Ankara: Nobel Kitabevi; 2001.
3. Gür A. Özürlülerin Sosyal Yaşama Uyum Süreçlerinde Sportif Etkinliklerin Rolü. Ankara: T.C. Başbakanlık Özürlüler İdaresi Başkanlığı Yayınları; 2001.
4. Dursun OB, Erhan SE, Ibiş EÖ, Esin IS, Keleş S, Şirinkan A, et al. The effect of ice skating on psychological well-being and sleep quality of children with visual or hearing impairment. Disabil Rehabil. 2015;37(9):783-9. [Crossref] [PubMed]
5. Meyen EL, Skrtic TM. Special Education and Student Disability. 1st ed. Denver, Colorado: Love Publishing Company; 1995.
6. Roger C. Hearing impairments. In: Horvat M, ed. Physical Education and Sport for Exceptional Students. 1st ed. USA WMC: Brown Pubs.; 1990. p.156-68.
7. İbrahim H, Nor NEM, Hashim AHM, Zainuddin ZA. The change of direction speed performance of hearing-impaired netball players. Man in India. 2017;97(13):195-203. [Link]
8. Metgud DC, Topkar P. Balance and agility testing in normal and hearing-impaired children: a case-control study. Indian J Phys Ther Res. 2019;1(1):42-6. [Crossref]
9. Akınoğlu B, Kocahan T. The effect of deafness on the physical fitness parameters of elite athletes. J Exerc Rehabil. 2019;15(3):430-8. [Crossref] [PubMed] [PMC]
10. Jackson AS. The evolution and validity of health-related fitness. Quest. 2006;58(1):160-75. [Crossref]
11. Šimonek J, Horička P, Hianik J. The differences in acceleration, maximal speed and agility between soccer, basketball, volleyball and handball players. Journal of Human Sport and Exercise. 2017;12(1):73-82. [Crossref]
12. Marques MC, González-Badillo JJ. In-season resistance training and detraining in professional team handball players. J Strength Cond Res. 2006;20(3):563-71. Erratum in: J Strength Cond Res. 2007;21(4):1002. Marques, Mario A Cardoso [corrected to Marques, Mário Cardoso]. [Crossref] [PubMed]
13. Günay M, Şıktar E, Şıktar E. Antrenman Bilimi. 2. Baskı. Ankara: Gazi Yayınevi; 2019.
14. Karacabey K. Sporda performans ve çeviklik testleri [Sport performance and agilitytests]. International Journal of Human Sciences. 2013;10(1):1693-704. [Link]
15. Lockie RG, Schultz AB, Callaghan SJ, Jeffriess MD, Berry SP. Reliability and validity of a new test of change-of-direction speed for field-based sports: the Change-of-Direction and Acceleration Test (CODAT). J Sports Sci Med. 2013;12(1):88-96. [PubMed] [PMC]
16. Nimphius S, Geib G, Spiteri T, Carlisle D. "Change of direction" measurement in division I American football players. J Aust Strength Cond. 2013;21(S2):115-7. [Link]
17. Aslan CS, Büyükdere C, Köklü Y, Özkan A, Özdemir FNS. Elit altı sporcularda vücut kompozisyonu, anaerobik performans ve sırt kuvveti arasındaki ilişkinin belirlenmesi [The relationships among body composition, anaerobic performance and back strength characteristics of sub-elite athletes]. International Journal of Human Sciences. 2011;8(1):1612-28. [Link]
18. Aktaş HN, Aslan CS. Amatör futbolcularda vücut kompozisyonu ile sürat arasındaki ilişkinin incelenmesi [The examination of relationship between body composition and velocity on amateur soccer players]. Journal of Çanakkale Onsekiz Mart University Sport Sciences. 2018;1(1):17-25. [Link]
19. Chaouachi A, Brughelli M, Chamari K, Levin GT, Ben Abdelkrim N, Laurencelle L, et al. Lower limb maximal dynamic strength and agility determinants in elite basketball players. J Strength Cond Res. 2009;23(5):1570-7. [Crossref] [PubMed]
20. Sheppard JM, Young WB. Agility literature review: classifications, training and testing. J Sports Sci. 2006;24(9):919-32. [Crossref] [PubMed]
21. Mohammad A, Tareq A. The relationship between body fat percentage with speed, agility and reaction time of male football players of Bangladesh. International Journal of Science Culture and Sport. 2016;4(4):453-60. [Link]
22. Ganjisaffar M, Aminaei M, Ranjbar R. Comparing anthropometric characteristics, body fat percentage and fitness between 13-17 years old girls. International Research Journal of Applied and Basic Sciences. 2013;7(6):375-81.
23. Gioldasis A, Bekris E, Michelinakis E, Gissis I. Relative age effect: relationship between anthropometric and fitness skills in youth soccer. International Journal of Sport Culture and Science. 2015;3(4):22-36. [Link]
24. Zemková E, Hamar D. Association of speed of decision making and change of direction speed with the agility performance. Functional Neurology, Rehabilitation, and Ergonomics. 2017;7(4):10-5. [Link]
25. Horička P, Hianik J, Šimonek J. The relationship between speed factors and agility in sport games. Journal of Human Sport & Exercise. 2014;9(1):49-58. [Crossref]
26. Bayraktar I. The influences of speed, cod speed and balance on reactive agility performance in team handball. International Journal of Environmental & Science Education. 2017;3(1):451-61. [Link]
27. Buttifant D, Graham K, Cross K. Agility and speed in soccer players are two different performance parameters. In: Spinks W, Reilly T, Murphy A, eds. Science and Football IV. 1st ed. London and New York: Routledge; 2001. p.329-32.
28. Sassi RH, Dardouri W, Yahmed MH, Gmada N, Mahfoudhi ME, Gharbi Z. Relative and absolute reliability of a modified agility t-test and its relationship with vertical jump and straight sprint. J Strength Cond Res. 2009;23(6):1644-51. [Crossref] [PubMed]
29. Little T, Williams AG. Specificity of acceleration, maximum speed, and agility in professional soccer players. In: Reilly T, Cabri J, Araujo D, eds. Science and Football V. 1st ed. London and New York: Routledge; 2003. p.289-96.
30. Spaniol F, Flores J, Bonnette R, Melrose D, Ocker L. The relationship between speed and agility of professional arena league football players. The Journal of Strength and Conditioning Research. 2010;24(1). [Crossref]
31. Draper JA, Lancaster MG. The 505 test: A test for agility in the horizontal plane. Australian Journal for Science and Medicine in Sport. 1985;17(1):15-8.
32. Açak M, Karademir T, Taşmektepligil Y, Çalışkan E. İşitme engelli futsal sporcularının çeviklik ve görsel reaksiyon zamanının karşılaştırılması [The examination of agility and visual reaction values of hearing-impaired futsal sportsmen]. Selçuk University Journal of Physical Education and Sport Science. 2012;14(2):283-9. [Link]
33. Atar Ö, Tetik S, Koç MC, Koç H. 18 age period's effect on balance, agility, reaction time and movement speed on the hearing-impaired people. Advances in Biological Research. 2016;10(2):101-5. [Link]
34. Ciğerci AE, Cengizhan PA, Cicioğlu İ, Günay M. 9-15 yaş grubu işitme engelli ve işitme engelli olmayan öğrencilerin bazı fizyolojik ve motorik özelliklerinin değerlendirilmesi [The evaluation of some physical and motor features of the students aged 9-15 with hearing impaired or not]. Selçuk University Journal of Physical Education and Sport Science. 2011;13(Additional Issue):35-42. [Link]
35. Rajendran V, Roy FG. An overview of motor skill performance and balance in hearing impaired children. Ital J Pediatr. 2011;37:33. [Crossref] [PubMed] [PMC]