

Correlations between VO_{2max} and match distance running performance of soccer players with visual impairment

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Abstract

Background

Aerobic capacity is crucial for the performance of soccer players. However, the relationship between aerobic capacity and the running performance of visually impaired soccer players is not clear.

Aims

The aims of this study were: (a) to determine the differences of lab measured VO_{2max} between athletes and sedentary with visual impairment (VI); and to assess the relationship between lab measured VO_{2max} of soccer players with VI (b) with the total distance that was covered in a soccer match and (c) with physiological parameters during soccer match.

Methods

Six male soccer players with VI and six male sedentary people with VI participated in this study. An analyzed match running performance of the six soccer players during soccer matches took place using a global positioning system. VO_{2max} of all the participants was measured in a laboratory.

Results

Soccer players' weight was 33% lower and their BMI was 23% lower than this of the sedentary men ($p = .023$, $\eta^2 = .457$ & $p = .038$, $\eta^2 = .394$ respectively). The relative with body mass VO_{2max} of athletes was 42.9% higher in comparison with sedentary men with VI ($p = .002$, $\eta^2 = .755$). No correlations were found between VO_{2max} and match running performance ($p = .679$) and other parameters during the match in soccer players with VI.

Conclusions

The results demonstrate that soccer players presented more healthy anthropometric and physiological characteristics than sedentary people with VI. The match running performance depends on the tactical role of each player in the team and the rules of the match.

Introduction

Visual impairment is a sensory disability that affects about 36 million people worldwide [28]. For equal participation in sport, people with visual impairment are categorized under three sections (B1, B2, B3). B1 category includes people that have or do not have light perception and cannot recognize any items.

Visual acuity is also stated with logMAR, which (LogMAR) stands for the logarithm of the maximum angle of resolution (International Blind Sports Federation (IBSA), 2018 and it presents more than 2.6 points according to the IBSA classification system [11].

Previous studies have shown that visual impairment is associated with low quality of life [16] as it causes a variety of difficulties in daily activities and limiting interactions and independence. One significant problem that this particular population has faced is the sedentary lifestyle due to difficulties in transportation and mobility [22].

According to researchers, [12] people with visual impairment who participated in sporting activities had a higher quality of life compared to those who had a sedentary lifestyle. Participation in sporting activities seems to reduce the sense of pain and at the same time improve mental health [12, 16]. Generally speaking, the improvement of physiological variables can help people with disabilities to be healthier and more satisfied with their life [28]. Furthermore, the physical activity of people with visual impairment improves their social life because in most sports they socialize with other people, especially in team sports [7] which has a positive impact on their life satisfaction.

There are many sports designed with rules adapted for this particular disability (visual impairment) (judo, wrestling, cycling, and blind soccer 5-a-side) but there are also sports that have their own unique set of rules like goalball, and beep baseball [7, 18].

There is a dearth of literature dedicated to people with visual impairment playing soccer. This is concerning because for a variety of issues such as the occurrence of injuries, the physical profile of soccer players, cardiorespiratory function, the effect of training on body composition the internal and external workload that soccer players receive and the analysis of technical elements of the sport [7, 9, 17], there is no specific data and often generalizations are made by other populations. Nevertheless, the information on the maximum oxygen uptake of soccer players with visual impairment is very limited.

Aerobic capacity can be improved with both continuing endurance training and high tension interval training [21]. Aerobic capacity is particularly important for the performance of players in soccer and previous studies have reported a correlation between the distance covered during the match and the maximum oxygen uptake [25]. Nonetheless, in a recent study using global positioning system (GPS) technology, studies have shown that there is no correlation between the running distance covered by soccer players during the match and the maximum oxygen uptake [19]. It has also been reported that an improvement of VO_{2max} by 6% may increase the running performance during the match, the number of sprints, and the number of actions with the ball [10]. In addition, high levels of aerobic capacity helps soccer players cope with the demands and physical challenges of the match [13] and have faster recovery between the intense actions during the match [2].

The studies that focus on the aerobic capacity of visual impairment people (soccer players and sedentary) are limited and there is not enough data to compare these two populations. Also, a positive relationship (between VO_{2max} and match running performance) could affect the way of training of soccer

players and would help the trainers to estimate players' match running performance via a laboratory measurement. However, no research to date has dealt with the relation between the VO_{2max} index and covered distances in soccer players with visual impairment. Therefore, it is assumed that soccer players with higher VO_{2max} will cover longer distances during soccer match.

We planned this study to: (a) determine the differences of VO_{2max} between soccer players and sedentary men with visual impairment; (b) to assess the relationship between VO_{2max} of players with visual impairment with the distance that was covered in a soccer match and (c) to describe a profile of physiological parameters and distance running during a soccer match.

Methods

Participants

Twelve participants with visual impairment (B1 category) agreed to participate in this study. This included six soccer players practicing for 13 to 20 years and six sedentary men who did not participate in any kind of physical exercise for at least six months. Six participants had congenital visual impairment and six had an acquired visual impairment (3 = athletes, 3 = sedentary). For those players who had developed blindness of acquired nature, the age of onset was 9.3 ± 2.1 years but they had not played soccer before their loss of sight. The evaluation of the severity of vision loss was based on an ophthalmological examination. The inclusion criteria were as follows: visual impairment (less than 20/200 and the field of vision limited to 20° legal visual impairment [11]; no medical contraindications to participate in the research; and male sex. Exclusion criteria were as follows: the coexistence of other disabilities and diseases, and taking medications that could affect the results of the analyses. Soccer players have been involved in the sport for at least 4 years in a local soccer team. All participants met their daily obligations for the study.

Procedures

All the players who participated in the present research completed the full time of the match, which lasted 2×25 min, while all goalkeepers were excluded from the study. The soccer players participated in 5 matches. The soccer players participated in two training sessions with the team on the field (for 75 min each training). Each of the training involved physical condition exercise, technical and tactical exercises. Also, they participated in two strength training sessions in the gym every week (for approximately 90 min each training).

All measurements were conducted under field conditions on natural or artificial grass of the 5th generation. Also, the matches were performed on non-raining days where the wind speed did not exceed 1 m/s. The soccer trainings were performed every Tuesday and Thursday. The trainings at the gym were performed every Wednesday and Friday.

All procedures and any possible risks and discomforts were fully explained in detail to participants, before the start of the study. There were no caffeine beverages, smoking consumption, or meals for at least 3 h before the testing. All the participants signed a consent form for their participation. The study was approved by the ethical committee of the Department of Physical Education and Sports Science, according to the ethical standards in exercise and sports research with disabilities. Participants' characteristics are shown in Table 1.

Table 1
Participants' characteristics.

	Soccer players (n = 6)			Sedentary people (n = 6)			p	η^2	U
	Percentiles	Percentiles		Percentiles	Percentiles				
	median	25th	75th	median	25th	75th			
Age (y)	27	21	35.5	24.5	21.5	34	.936	< .001	17.5
Height (cm)	169.5	164	176.5	173	167	178.8	.173	.169	9.5
Weight (kg)	70	64.4	78.3	81.1	69.9	93.2	.023	.457	4
BMI	25.5	22.5	27.7	29.2	27.1	37.2	.038	.394	5
Body Fat (%)	21	19.8	22.3	24.5	20.5	27.8	.002	.766	< .001
Lean body mass (kg)	54.6	51.5	62.5	61.8	53.4	69.3	.032	.282	7
Congenital /Acquired	3 / 3			3 / 3					

Experimental Approach To The Problem

A cross-sectional protocol approached the problem of the study. The VO_{2max} was measured in the lab and running and cardiorespiratory parameters were measured during five soccer matches. The 12 participants of the study were divided into two groups of six (soccer players and sedentary). All of them performed anthropometric and VO_{2max} measurements. The players participated in five soccer matches where physiological indicators and match running distance were measured. These indexes checked whether they were correlated to the VO_{2max} measured in the laboratory.

One week before the beginning of the study the players familiarized themselves with the tests. Testing was incorporated within the laboratory and teams' field. More specifically, the anthropometric and VO_{2max} measurements were completed during the first visit to the laboratory. At the beginning of the VO_{2max} measurement, all participants performed a 10-min warm-up and stretching, and at the end a 10-min cool-

down period. In the field, the soccer players before each soccer match performed a standardized 25 min warm-up consisting of five min sub-maximal running, five min of stretching exercises, ball-handling exercises for five min, three repetitions of 15-m run-outs at approximately 90% of maximal speed, and four min of active recovery. VO_{2max} measurements were performed in the same conditions and the players avoided intense exercise in the preceding 24-h. The soccer matches were performed on a soccer field with synthetic grass.

Anthropometric Measurements

Body mass was measured using an electronic digital scale with the participants in their underclothes and barefoot. The height was measured to the nearest 0.1-cm (Seca 220e, Hamburg, Germany). Body mass index (BMI) was calculated (Kg/m^2). Body fat (%) was assessed with skinfold measurement (4-fold method): biceps (S1), triceps (S2), suprailiac (S3), and subscapular (S4) by specific (Lafayette, Ins. Co., Indiana)

The percentage of body fat was estimated by the equation of Siri (1956) [24]:

$$BF (\%) = [(4.95/D) - 4.5] \times 100$$

Maximal Oxygen Consumption (Vo) Assessment

VO_{2max} is the maximum rate of O_2 uptake as measured during large muscle mass exercise such as running [1], which is widely considered to be the gold standard measurement of integrated cardiopulmonary muscle oxidative function. This test was carried out in the laboratory and its results show the level of aerobic capacity of the athlete. The most accurate measurement of VO_{2max} , which is referred to as the “gold standard”, consists of maximal laboratory testing on the treadmill [5]. We use the treadmill to measure VO_{2max} because this kind of motion (walking-running) is similar to the movements in soccer matches. This index is used in assessing players’ aerobic capacity. VO_{2max} of soccer players was assessed in the morning. The room temperature was around 23°C and the relative humidity was 50%. The cardiorespiratory VO_{2max} test was performed on a treadmill (Pulsar; h/p/Cosmos, Nussdorf-Traunstein, Germany) using a continuous protocol until exhaustion, consisting of eight two-minute stages. The initial grade was 0% and the speed was at 4 km/h for warm-up. In the basic phase of the test, the grade was set to 3% and speed at 5 km/h. Speed was constant throughout the test, while grade was being increased by 2% every 2min. After the final stage, a cool-down session took place for 2min, at 2 km/h and 0% grade. Before study measurements, a pilot study was conducted. VO_{2max} and cardiorespiratory indices were measured via a breath-by-breath ergspirometric system (Oxycon Pro; Jaeger, Wurzburg, Germany). The analyzers had been calibrated before measurements. The highest VO_{2max} value recorded was accepted as the VO_{2max} , after achieving the stabilization of VO_{2max} for at

least five measurements (steady-state). Moreover, during the testing, the following parameters were recorded: heart rate (HR), maximal HR, and respiratory exchange ratio (RER).

The VO_{2max} was achieved when at least two of the four criteria following, were met: a) HR exceeded 95% of the expected maximal HR predicted by formula $220 - \text{age}$; b) leveling off (plateau) of VO_{2max} despite the increase in treadmill grade; c) a respiratory exchange ratio (RER) higher than 1.1; d) the subject was no longer able to continue walking despite verbal encouragement.

Global Positioning System (Gps) Analysis

HR data from the match were recorded using the Polar Team Pro (10Hz) (Polar Electro Oy, Kempele, Finland). The recording of the HR began when the athlete wore his monitor. All the values were taken directly from the Polar Team2 Pro software. In matches, each player wore the same GPS device to avoid any existing interunit variation, and at the end of the match, data was analyzed, and 4 indices were used for the total match (total distance, mean and maximum movement velocity, mean heart rate).

Statistical analysis

All the statistical analysis was performed using SPSS (version 24.0; SPSS Inc., Chicago, IL, USA). Mann-Whitney U test were used to evaluate differences between sedentary and soccer players' anthropometric characteristics and performance. Effect sizes were estimated by calculating partial eta squared and were classified as small (.01 to .058), medium (.059 to .137) or large (.138 or higher) according to Cohen (1988) [4]. Finally, the correlation analysis by Pearson's method was used to examine relationships between VO_{2max} and the rest of the physical values during the match. The level of statistical significance was set at $p < .05$.

Results

No correlations were found between VO_{2max} and the match running performance. No correlations were found between VO_{2max} and other parameters during the match, in soccer players with visual impairment (mean and max velocity, mean heart rate). Correlations are shown in Table 2.

The total distance covered by the soccer players was 1,820m (SD = 342, CI95%=1,670-1,980). The average speed was 2.03 km/h (SD = 0.48; CI95%=1.95–3.17), while the maximum speed was 8.37 km/h (SD = 1.36, CI95%=6.98–10.3). The average HR during the match was 159 beats/min (SD = 10, CI95%=154–177).

Soccer players' weight and BMI with visual impairment were 33% and 23% lower than this of the sedentary men with visual impairment ($p = .023$, $\eta^2 = .457$ & $p = .038$, $\eta^2 = .394$ respectively). Also, soccer players' body fat was lower than the equivalent body fat of sedentary men ($p = .002$, $\eta^2 = .766$). Additionally, the relative body mass VO_{2max} and the relative lean body mass of athletes were 42.9% and

24.1% higher, respectively than the sedentary men ($p = .002$ & $p = .032$ respectively). The participants' cardiorespiratory parameters are presented in Table 3.

Table 2
Correlation between VO_{2max} and physiological parameters.

	Total distance		Mean HR		Mean velocity		Max velocity	
	r	p	r	p	r	p	r	p
VO2max Relative to body mass (ml/kg/min)	.217	.679	-.083	.876	.372	.468	-.156	.768
VO2max Relative to lean body mass (ml/kg/min)	.158	.765	-.170	.747	.388	.444	-.141	.790

Table 3
The average values of participants' cardiorespiratory parameters.

	Soccer players			Sedentary people			p	η^2	U
	Percentiles			Percentiles					
	median	25th	75th	median	25th	75th			
HRmax (b/min)	161	144	186	162	147	176	.995	< .001	18
RER	1.05	1	1.1	1.05	0.98	1.1	.841	< .001	18
VO2max (L/min)	2.9	2.63	3.17	2.77	2.6	3.05	.157	.149	10
VO2max (ml/kg/min) Relative to body mass	41.15	36.93	43.93	33.95	30.18	41.78	.002	.755	< .001
VO2max (ml/kg/min) Relative to lean body mass	51.06	47.48	55.29	44.97	41.82	51.66	.004	.674	1

Discussion

The results of the study in relation to the research questions show that: a) soccer players with visual impairment showed a higher value in VO_{2max} compared to sedentary people; b) there was no correlation of VO_{2max} with the distance covered during the match; c) the total distance covered during the match was about 2 km with an average speed of 2 km/h and a maximum speed of about 8 km/h.

Relation Of VO_{2max} With Total Match Running Distance And Other Physiological Parameters

To our knowledge, this is the only study that investigates the relation of VO_{2max} to the distance that was covered during a soccer match for people with visual impairment. The findings showed that there were no correlations with the total running distance covered in soccer matches by athletes. In soccer players without visual impairment, there is only one study [19] that tests the relationship between VO_{2max} and match running performance (measured by GPS), which mentioned no correlations, like us. Other studies regarding soccer players without visual impairment indicated positive correlations between the performance in anaerobic field tests and the distances covered in a match [19]. At all levels and kinds of soccer matches, the tactical role, individual playing position, the opponent, and the impulse of stimulus degree of motivation can affect the correlation between VO_{2max} and match running performance. It has been shown that some contextual variables can affect external load like match running distance [7]. However, Gamonales et al., (2020) [8] in a tournament for individuals with visual impairment showed similar match running distance (1,416 to 1,877 m). There is no doubt that a high level of VO_{2max} is necessary for high performance in soccer, but all the above-mentioned factors can affect the match running performance.

Additionally, no correlations were observed between VO_{2max} and the other physiological parameters like mean heart rate, and mean and maximum velocity of the players during the soccer match. However, a study by Gamonales, et al., (2020) [8] on soccer players with visual impairment from three different countries (Spain, Italy, and Czech Republic) showed lower heart rate average values (~ 145 beats/min) during matches than the present study. Similar results were presented in a more recent study by the same laboratory [7] that was performed on 50 soccer players with visual impairment. The average heart rate was (M = 138, SD = 20 beats/min). These values are well below the value observed in the present study (M = 159, SD = 10 beats/min) with participants in the three studies having a similar age (M = 30.9, SD = 11.5 vs M = 30.8, SD = 11.2 vs M = 28, SD = 2.7, respectively).

Differences On Anthropometric Characteristics Between Soccer Players And Sedentary People

It should be mentioned that the targets of the present study were to examine the differences of anthropometric characteristics and VO_{2max} between sedentary men and soccer players with visual impairment and the possible relationship between VO_{2max} and parameters during a soccer match. In general, the findings of the present study showed that soccer players had lower weight and had lower BMI than sedentary men. The overweight of people with visual impairment or visual impairment may be partly connected to a lack of habitual physical activity [14]. Habits related to physical activity during childhood are also adopted during adulthood. Also, an obese child is very likely to be an obese adult [15]. It is crucial for the youth with visual impairment to adopt an active lifestyle and participate in any kind of sport. The

BMI of the participants (soccer players) of the present study ($M = 25.3$, $SD = 3.7$) was similar to the values mentioned in a previous study ($M = 25.04$, $SD = 3.2$) [8].

Another important finding of the present study was that soccer players showed greater values of VO_{2max} than sedentary men. A crucial ability of soccer players is aerobic capacity. The most useful index to assess this capacity is the VO_{2max} , which is the ability of the body to maximize the use of oxygen during maximal effort. Despite the adjustments of the rules for soccer players with visual impairment, the sport is especially demanding for aerobic capacity. In the present study, the VO_{2max} of the soccer players was higher than this of the sedentary men. Both values were lower than the reported values of sedentary men without visual impairment. Although the absolute value of VO_{2max} between players and non-players differed only by 8.6%, the relative value of VO_{2max} differed by 42.9%. This indicates the significant influence of weight on VO_{2max} . The studies that were performed on the people with visual impairment used different methods to measure cardiorespiratory, muscle strength, and body fat and it is difficult to compare their results [15]. This was the first study that compares the VO_{2max} of soccer players and sedentary men with visual impairment. The soccer players showed a higher absolute and relative value of VO_{2max} in comparison to the visual impairment sedentary men.

Participation in sports helps to adopt healthy habits, develops self-esteem, and builds social skills. Playing soccer, which is a dynamic and continuous match, has a positive effect on a player's anthropometric characteristics and one's aerobic capacity. Previous studies have mentioned that athletes with visual impairment presented similar anthropometric values to other athletes [27] and have similar levels of physical fitness, cardiopulmonary function, and lower limb muscle strength as those of their active counterparts with no visual impairment [23]. Social life is very important for the health of people and soccer could be a way to help people with visual impairment become more sociable.

However, people with visual impairment present to have lower physical activity levels than their peers with physical or chronic disabilities. Social and self-imposed barriers are the main issues preventing people with visual impairment from participating in any sporting activity [26]. Previous studies have mentioned that physical activity may reduce the risk of developing depression, improve the quality of life and generally improve the mood of the people [20]. It is very important to encourage people with visual impairment to participate in team sports. Soccer is a team sport, in which a player is part of a group. It has been mentioned in a previous study that life satisfaction increased when the people joining exercise groups [6]. In another study, researchers revealed that Torball practice improves the emotional well-being and social abilities of people with visual impairment [3].

As for the limitation of the study, a greater sample size would be better for safer conclusions. Also, we need to mention that all the participants belong to the B1 category of visual impairment, so the results of this study are representative of this group of participants and cannot be generalized to all people with visual impairment. Additionally, in the present study the demographic characteristics of the sample were not taken into account. Finally, the cross-sectional study design cannot indicate a causal relation between soccer participation and physical condition. Reducing these limitations in future research, will create a

clearer picture of VO_{2max} of visually impaired soccer players and the distance they cover during a soccer match.

Conclusions

In conclusion, the results demonstrate that players' match running performances do not depend on the index of VO_{2max} . Additionally, soccer players with visual impairment have significantly greater VO_{2max} than sedentary men. Finally, sedentary men were presented bigger BMI index than soccer players. As we mentioned above, this study design does not allow us to believe that the healthiest physiological indicators displayed by soccer players are the result of their participation in the sport and the training process they carry out. However, it certainly contributes to this.

Declarations

The authors have no competing interests to declare that are relevant to the content of this article.

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Compliance with Ethical Standards

Conflicts of Interest: The authors declare no conflict of interest.

Informed consent: All the participants signed a consent form for their participation. The study was approved by the ethical committee of the Department of Physical Education and Sports Science, according to the ethical standards in exercise and sports research with disabilities.

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References

1. Astrand PO, Rodahl K (1986) Text book of work physiology. McGraw-Hill.
2. Brown PI, Hughes MG, Tong RJ (2007) Relationship between Vo_{2max} and repeated sprint ability using non-motorised treadmill ergometry. *J Sports Med Phys Fitness* 47:186–190.
3. Castagna C, Manzi V, Impellizzeri F, Weston M, Barbero Alvarez JC (2010) Relationship between endurance field tests and match performance in young soccer players. *J Strength Cond Res* 24, 3227–3233. <https://doi.org/10.1519/JSC.0b013e3181e72709>
4. Cohen J (1988) *Statistical Power Analysis for the Behavioral Sciences*. Lawrence Earlbaum Associates: Hillsdale, Michigan.
5. Di Salvo V, Baron R, Tschan H, Calderon Montero FJ, Bachl N, Pigozzi F (2007) Performance characteristics according to playing position in elite soccer. *Int J Sport Med* 28:222–227.

<https://doi.org/10.1055/s-2006-924294>

6. Fox KR (1999) The influence of physical activity on mental well-being. *Public Health Nutrition* 2:411–418. <https://doi.org/10.1017/S1368980099000567>.
7. Gamonales JM, León K, Rojas-Valverde D, Sánchez-Ureña B, Muñoz-Jiménez J (2021) Data Mining to Select Relevant Variables Influencing External and Internal Workload of Elite Blind 5-a-Side Soccer. *Int J Environ Res Public Health* 18(6), 3155. <https://doi.org/10.3390/ijerph18063155>
8. Gamonales JM, Muñoz Jiménez M, Mancha-Triguero D, Ibáñez SJ (2020) The influence of the competition phase and the result of the match on the competitive demands in football 5-a-side for the visually impaired. *Int J Perform Anal Sport* 21(1):1–11. <https://doi.org/10.1080/24748668.2020.1833640>
9. Gamonales JM, Muñoz-Jiménez J, León K, Ibáñez SJ (2019) Effectiveness of the Launch at FA5 for Blind Persons in 2016 Paralympic Games. *Revista Internacional de Medicina y Ciencias de la Actividad Física y del Deporte* 19:745–764. <https://doi.org/10.15366/rimcafd2019.76.012>
10. Helgerud J, Engen LC, Wisloff U, Hoff J (2001) Aerobic endurance training improves soccer performance. *Med Sci Sports Exer* 33:1925–1931. <https://doi.org/10.1097/00005768-200111000-00019>
11. IBSA. International Blind Sports Federation; (2018, December 10). <https://ibsasport.org/growing-blind-sports/classification/>
12. Ilhan B, Idil A, Ilhan I (2021). Sports participation and quality of life in individuals with visual impairment. *Irish Journal of Medical Science* 190:429–436. <https://doi.org/10.1007/s11845-020-02285-5>
13. Impellizzeri FM, Rampinini E, Marcora SM (2005) Physiological assessment of aerobic training in soccer. *J Sport Sci* 23:583–592. <https://doi.org/10.1080/02640410400021278>
14. Kakiyama T, Koda Y, Matsuda M (1999) Effects of physical inactivity on aortic distensibility in visually impaired young men. *Eur J Appl Physiol Occup Physiol* 79(3):205–211. <https://doi.org/10.1007/s004210050497>
15. Koutedakis Y, Bouziotas C (2003) National physical education curriculum: motor and cardiovascular health related fitness in Greek adolescents. *Br J Sports Med* 37(4):311–314. <https://doi.org/10.1136/bjism.37.4.311>
16. Langelaan M, De Boer MR, Van Nispen RM, Wouters B, Moll AC, Van Rens GH (2007) Impact of visual impairment on quality of life: a comparison with quality of life in the general population and with other chronic conditions. *Ophthalmic Epidemiology* 14:119–126. <https://doi.org/10.1080/09286580601139212>
17. Magno e Silva MP, Morato MP, Bilzon JLJ, Duarte E (2013) Sports Injuries in Brazilian Blind Footballers. *Int J Sports Med* 34:239–243. <https://doi.org/10.1055/s-0032-1316358>
18. Malwina KA, Krysztof M, Piotr Z (2015) Visual impairment does not limit training effects in development of aerobic and anaerobic capacity in tandem cyclists. *J Hum Kin* 48:87–97. <https://doi.org/10.1515/hukin-2015-0095>