EFFECTS OF INTEGRATED TRAINING WITH THE USE OF ACTION PERCEPTION LIGHT SENSORS ON AGILITY, QUICKNESS AND MOTOR REACTION IN FEMALE VOLLEYBALL PLAYERS

EFFETTI DELL'ALLENAMENTO INTEGRATO CON UTILIZZO DEI SENSORI LUMINOSI DI PERCEZIONE AZIONE SU AGILITÀ, RAPIDITÀ E REAZIONE MOTORIA NELLE GIOCATRICI DI PALLAVOLO

Nicola Mancini
University "Babes Bolyai", Cluj-Napoca, Romania
nicola.mancini@unifg.it
https://orcid.org/0009-0005-4566-6417
Siria Mancini
University of Foggia, Foggia, Italy
siria_mancini.585707@unifg.it
https://orcid.org/0009-0003-5584-6409
Emilia Florina Grosu
University "Babes Bolyai", Cluj-Napoca, Romania
emilia.grosu@ubbcluj.ro
https://orcid.org/0000-0002-2846-9586

Double Blind Peer Review

Citazione

Mancini N., Mancini S., Grosu E.F., (2023) Effects of integrated training with the use of action perception light sensors on agility, rapidity and motor reaction in female volleyball players, Giornale Italiano di Educazione alla Salute, Sport e Didattica Inclusiva - Italian Journal of Health Education, Sports and Inclusive Didactics. Anno 7, V 2. Edizioni Universitarie Romane

Doi:
https://doi.org/10.32043/gsd.v7i2.846

gsdjournal.it
ISSN: 2532-3296
ISBN: 978-88-6022-470-5

ABSTRACT

In volleyball, the use of light sensors of perception of action, into an 6-week training program, can improve motor reaction times, quickness of movement and agility in athletes, which represent success factors in sports performance. 24 female players (age 20.3±0.5 years), were assigned to control (CG; n=12) and experimental (EG; n=12) groups. The difference of the results (T-test) between pre and post test, showed that the EG compared to the CG has significantly better scores in all tests.

Nella pallavolo l'utilizzo di sensori luminosi di percezione azione, integrati in un programma di allenamento di 6 settimane, possono negli atleti migliorare, tempi di reazione motoria, rapidità di movimento e agilità che rappresentano fattori di successo della prestazione sportiva. Ventiquattro giocatrici (età 20.3 ±0.5 anni) sono state assegnate a gruppi di controllo (n=12) e sperimentale (n=12). La differenza dei risultati (T-test) tra pre e post test ha mostrato come il gruppo sperimentale ha punteggi significativi migliori in tutti i test rispetto al gruppo di controllo.

KEYWORDS
Reaction times, agility, quickness, volleyball
Tempi di reazione, agilità, rapidità, pallavolo

Received 11/04/2023
Accepted 2/05/2023
Published 20/05/2023

Introduction

Volleyball is an open skill situation sport in which the physical performance of the players together with the technical and tactical factors determine the success in competitions (Lidor & Ziv, 2010). Volleyball players must have medium to high levels of sensory skills and cognitive functions as essential prerequisites, as well as physical and motor skills. There are many scientific studies that help to try to make the physical performance of volleyball players more and more efficient which, together with the technical-tactical factors, determine success in competitions (Silva & Tumelero, 2007). Short reaction times (Nuri et al., 2013), quickness and agility of movement (Gabbett & Georgieff, 2007) are important qualities for success. In sport, the ability to react, quickness and agility of human movement are closely related to each other as they interact continuously for the realization of the motor act. In this study we wanted to investigate the effects of the training method enriched with specific exercises that make use of action perception technological tools to improve reaction times, quickness and agility in a sample of young volleyball players, compared to a training program with traditional methodology. In recent years, in the sports environment, we saw a large diffusion and use of technological tools that produce series of luminous visual signals with LED technology to train and test cognitive functions, reaction times, quickness and agility of movement in short spaces (Appelbaum & Erickson, 2018). Digital instruments built with a simple, inexpensive and not particularly complex technology are on the market, among them: FitLight System® (Fitlight System, 2022), Blazepod® (BlazePod™, 2023), ReactionX (ReactionX, 2022) to name a few. These systems have very similar characteristics to each other, for example they contain pre-set and modifiable programs to train simple or complex reaction capacity, memory, quickness and agility of movements using sequences of lights of different colors proposed in sequential succession or random. New technologies can therefore take on an added value to the training methodology by becoming an enriching factor in favor of performance.

1. Reaction Time

Motor reaction time is defined as the time interval between the perceptive stimulus and the consequent onset of the motor response, its measurement is considered as an excellent indicator for evaluating the ability of the human cognitive system to process the information (Jensen, 2006). Simple Reaction Time (RTs) is defined as the time interval between the appearance of a stimulus, its detection and the response provided (Jayaswal, 2016). In volleyball, defending an opponent's attack on the field a few meters from the net where the ball, which weighs on average 280 g and can reach speeds close to 100 km/h, causes the receiver to have excellent reaction times to a visual stimulus represented by the trajectory of the ball. These skills are necessary for athletes to competently perform their motor skills in sport (Kuan et al., 2018) and above all in volleyball where game dynamics and very short reaction times, which change according to the various situations, are extremely important (Mroczek, 2007).

2. Quickness and Agility

Quickness is defined as the ability to reach, under certain conditions, the maximum possible speed of reaction and movement, on the basis of cognitive processes, maximum efforts and the functionality of the neuro-muscular system (Grosser & Renner, 2007). In this study, among the different forms of quickness according to Schiffer (1993) classification, we took into consideration: a) the quickness of the single movement: perform acyclic movements at maximum speed against little resistance; b) the frequency of movements: perform cyclic movements at maximum speed against little resistance. The acyclic quickness of the upper and lower limbs, for example, is a relevant aspect in the specific technical gestures of volleyball such as for example that of the arm in the fundamental of the smash, the rapid movement of the arms when defending a very fast ball or the rapid movement of the feet close together during movements in the various areas of the field.

Agility has been defined by many authors as the ability to change direction quickly (Bloomfield et al., 1994), to change direction quickly and accurately (Johnson & Nelson, 1969) but also the ability to change direction, accelerate and brake rapidly (Miller et al., 2001). Other authors propose a new definition of agility in sport as: “a rapid movement of the whole body with change of speed or direction in response to a stimulus'' (Sheppard & Young, 2006). Agility is an important quality that contributes significantly to successful sports achievements (Sekulic et al., 2017). In addition to jumping, volleyball is characterized by movements with changes of direction that occur in various parts of the playing field, therefore the ability to change direction as needed quickly and precisely is considered by many to be an integral part of motor and sports performance (Keogh et al., 2003).

3. Materials and methods

3.1. *Participants*

In this randomized controlled study 24 female volleyball players participating in the B2 national championship of the FIPAV (Italian Volleyball Federation) took part voluntarily. The sample was divided into a control group (CG) of 12 female players (X ± SD: age 20.1 ± 0.7 years; height 176.7 ± 6.2 cm; body mass 67.1 ± 7.8 kg) and an experimental group (EG) of 12 female players (X ±SD: age 20.3 ±0.5 years; height 175.2 ±5.1 cm; body mass 68.7 ±8.1 kg). The selection criteria were: the participants had to practice volleyball at a competitive level for at least 6 years, be in compliance with the certificate of competitive sport fitness, have completed the training program, have passed all the tests required in the study. Exclusion criteria for study participation were: any recent injury requiring medical attention, poor health and neurological adverse events e.g. seizures, incomplete participation in training and testing program, having had covid-19 infection in the period prior to 6 months from the start of the study.

3.2. *Research design and procedure*

The research was conducted during the pre-season physical and technical preparation period, therefore the players came from a period of approximately 2 months of summer break from the championship of the previous competitive season. The study lasted 6 weeks from August 22 to October 3, 2022. Initial tests (pre-test) and final tests (post test) were administered to all subjects, the order of administration of the tests was identical. From 22 August to 03 October 2022, the training program was implemented with the use of a technological system (*Fitlight System*, 2022) consisting of discs with luminous LEDs for the experimental group only (EG) and classic training, without using the technological system, for the group of control (CG). On the morning of 03 October 2022, the final tests (post-tests) were administered to both groups. During the 6-week exercise training, total daily and weekly exercise time was the same for both groups. On the weekdays of Monday, Tuesday, Thursday and Friday morning, both groups carried out the part of the physical work dedicated to motor reaction, quickness and agility. The CG followed a traditional type program with the use of a ladder, reactivity balls and delimiter cones while the EG in the same time about 26 minutes carried out exercises using luminous LED devices. All procedures conformed to the directives of the Declaration of Helsinki (2013). Informed consent was requested for data collection. The local Institutional Ethics Committee approved the study.

3.3. *Experimental study program with light sensors*

Four types of exercises lasting 60 seconds each, using light sensors were integrated into the program. In the first two exercises, the subjects were positioned standing, at a comfortable individual distance, in front of a black panel measuring 1x2 meters on which 8 LED pads were arranged equidistant from each other in a semicircle. In exercises three and four, the subjects had to move dynamically in space with rapid movements of the whole body in various directions, between 3 led discs that lighted up in a successive predefined/random manner, positioned on mobile trestles at a height of 1.5 m from the ground and distant between them 1 meter. A work station was dedicated to each exercise, the athletes had to complete a round of all the stations 3 consecutive times, a 2' break was foreseen between the exercises. Total activity time for each athlete was approximately 30 minutes including breaks. In each station at the end of each exercise, the Fitlight Trainer system uses software to detect the average times of each trial and the errors made. The results of each test were communicated to the subjects in order to stimulate them to improve during the same tests of the session.

3.4. *Measures and instruments*

Fitlight technology (Fitlight System, 2022) is a system made up of wireless LED technology lights connected to a tablet and managed by software. Each disc (diameter: 10 cm) in relation to the program used, emits light signals via LED lights or sound and is also equipped with proximity sensors. The system allows you to measure and record times in thousandths of a second for each contact. The lights can be arranged as desired in space at different distances or shapes and on different horizontal and vertical surfaces. Many studies show that FitLight technology is a reliable measurement tool for analyzing reaction times (Florkiewicz et al., 2014; Reigal et al., 2019).

3.4.1. *Hexagon Agility Test (HAT)*

Hexagon agility test (HAT) is described as "a measure of agility and quickness of the feet involving balance and coordination capacity" (Baechle et al., 1994). It has been shown that the HAT, as a field test, has excellent test-retest reliability when rigorous test procedures are followed (Beekhuizen et al., 2009). The test involves the subject facing forward, in the center of a hexagon drawn on the ground with adhesive tape. The length of each side is 24 inches (60.96 cm), each inner angle is 120 degrees. At the center of the hexagon is positioned solidly on the ground, a conductance platform connected to a chronometric detection system (Chronojump System, Barcellona). The test involves 6 successive round-trip jumps, successively overcoming each side of the hexagon. The test runs both clockwise and counterclockwise. The average time is calculated as a score, given by the sum of the total times of the clockwise and counterclockwise laps divided by 2. The best average time between the two trials administered was taken into consideration.

3.4.2. *Reaction Time simple Lower Limb (RTsLL)*

The measurement of simple lower limb reaction times was performed using the Reaction Time simple lower limb test (RTsLL; ICC/Rho: .74 * (95%CI: .34 and 0.92), $p < .001$) (Wilke et al., 2020). The subject is standing positioned in the center between eight LED lights (Fitlight System, 2022) arranged in a semicircular arrangement, the equidistant distance from the feet to the LED corresponded to the length of the lower limb between the ground and the tibial tuberosity (leg). Before deactivating the lights with your feet, ground contact is required in the starting/neutral position (shoulder-width position). The test has a duration of 45 s, during this period, the total average response time is calculated in thousandths of a second to switch off the lights which are activated in random succession, through the rapid movement of the preferred foot towards the corresponding LED. Each participant performed two trials with a 3-minute break, the best average time between the two trials was considered. In addition to quick reactions and attentiveness, this test requires speed of visual scanning and processing.

3.4.3. *Tapping Lower Limb (TLL)*

The test aims to measure the quickness of movement of the feet. The subject is seated on a suitable adjustable chair with one foot resting on the ground next to a 20 x 5 x 1 cm tablet fixed with adhesive tape, the leg perpendicular to the ground and the thigh-leg angle of approximately 90°. From this position at the start of the examiner, the subject begins the test with the preferred limb by performing 40 touches of the foot to the right and left of the board placed on the ground. It is allowed to hold the chair with the hands while it is not allowed to touch the tablet. With a Chronojump conductance platform (Chronojump System, Barcellona) the time in seconds/tenths to make 40 hits is detected; the test is repeated 2 times for each limb with an appropriate rest interval. The trial with the shortest time for each limb is considered. The total score is given by the average of the times in thousandths of a second between the two feet.

3.4.4. *Statistical Analysis*

Data were processed using SPSS vers. 25.0 (IBM Inc. Chicago). The distribution of each variable was examined using Shapiro-Wilk tests. The mean (X), standard deviation (SD), and difference of means (ΔX) were used as a descriptive statistical approach. In this study, t-test analyzes for independent and paired samples were applied, and Cohen's d and increase percentage (ip%) were calculated at the same time. The interpretation of Cohen's d (effect size) is established as follows: 0.1 - 0.2 small, 0.3 - 0.5 medium, 0.5 - 0.8 large, over 0.8 very large (Sawilowsky, 2009). The baseline statistical significance value for this study was selected at $p < 0.05$. The percentage increase (ip%) was calculated according to the following formula: ip% = [(Xpost – Xpre)/Xpre] * 100.

4. Results

The Shapiro-Wilk test results showed a normal distribution for all data. Student's t-test for independent samples was used to determine whether there is a statistically significant difference between the means of two independent groups (EG and CG) in each test administered. Levene's test for the presumed equal variances was found to be significant for all the tests, therefore the null hypothesis, i.e. that there are equality of the variances, are discarded.
Therefore, having accepted the hypothesis of non-equality of the variables, table 1 (Tab. 1) shows the results in the RTsLL, TLL and HAT tests in the pre and post intervention. It should be noted that in the pre-test phase no significant differences were found between the average times (DX) obtained in all the tests (RTsLL (s), DX = -.007 s, p = .582; TLL (s), DX = .05 s, p = .795; HAT (s), DX = -.009 s, p = 0.926). This shows that at the start the groups achieved very similar average times in each trial so both groups start from the same level of performance. Differently, in the post-test phase, significant differences were found between the average times (DX) obtained in all trials (RTsLL (s), DX = -.07 s, p <0.05; TLL (s), DX = -.84 s, p <.05; HAT (s), DX = -.629 s, p <.05). Since p <.05 in all tests, we can reject the null hypothesis of homogeneity of the means and therefore assume that the differences observed in both groups are not due to chance but to the training effect.

Table 1. T-test results for independent groups EG and CG in RTsLL, TLL and HAT tests in pre- and post-intervention (n=24).

Test	Group	X ±SD	DX	95% CI Lower Upper	t	p	d
RTsLL (s) pre	EG (n=12)	.611 ±.027	-.007	-.029	-.56	.582	.26
	CG (n=12)	.618 ±.027		.017			
RTsLL (s) post	EG (n=12)	.520 ±.032	-.07	-.096	-5.53	.000*	2.41
	CG (n=12)	.590 ±.029		-.043			
TLL (s)	EG (n=12)	9.153 ±.489	.05	-.345	.26	.795	.11

pre	CG (n=12)	9.103 ±.444		.445			
TLL (s) post	EG (n=12)	8.170 ±.473	-.840	-1.202 -.478	-4.81	.000*	2.23
	CG (n=12)	9.010 ±.376					
HAT (s) pre	EG (n=12)	4.796 ±.183	-.009	-.211 .193	-.09	.926	.03
	CG (n=12)	4.805 ±.284					
HAT (s) post	EG (n=12)	4.119 ±.286	-.629	-.864 -.394	-5.56	.000*	2.35
	CG (n=12)	4.748 ±.268					

RTsLL—Reaction Time Lower Limb; TLL—Tapping Lower Limb; HAT—Hexagon Agility Test; X ± DS—mean ± standard deviation; DX—difference of means; 95% C.I., interval of confidence with lower and upper levels; t—Student's t-test; p—statistical level of probability; d—Cohen 's effect size. *Significant at p<.05; T—value of t at the significance level of .05 = 2.201.

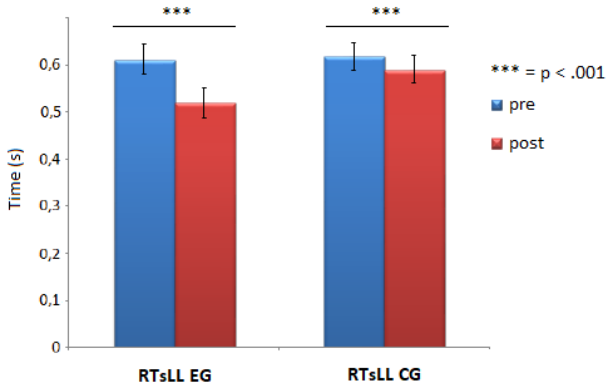
Observing the mean differences between pre- and post-tests (Graph 1 and Graph 2) in each group, we can see a significant improvement in the mean execution times in all tests, even if with different magnitudes between EG and CG. In table 2 (Tab. 2) we can see how the EG obtains performance improvements with significant decreases in mean times (id%) of -14.9% in the RTsLL (DX =-.091 s, t = 44, p <.05, d = 12.7), -10.7% in the TLL (DX =-.983 s, t = 43.1, p <.05, d = 12.4) and -14.1% in the HAT (DX =-.677 s, t = 19.0 , p <.05, d = 5.5). The value of the d-Cohen 's highlights that the relationship between the variables in the EG is very strong in all tests as its value is much higher than 0.8 (Sawilowsky, 2009). It can therefore be argued that the main cause of the decrease in average times can be associated with training performed with the use of exercises that make use of action perception devices. The CG achieves significant but minor performance improvements (Tab. 2), with decreases in mean times (id%) of -4.5% in RTsLL (DX = -.028 s, t = 11.0, p <.05, d = 3.2), -1.0% in the TLL (DX =-.093 s, t = 2.8, p <.05, d = 0.8) and -1.2% in the HAT (DX =-.057 s, t = 3.3, p <.05, d = 1.0). Although the improvements in mean CG execution times recorded in the tests are small, it should be noted that the calculated d-Cohen's value is classified as very large (d >.8). Therefore we can argue that in the present study a traditional training program can be associated with an improvement in performance, even if slight, in the tests administered.

Table 2. T-test results for paired samples EG and CG in RTsLL, TLL and HAT tests in pre- and post-intervention (n=12).

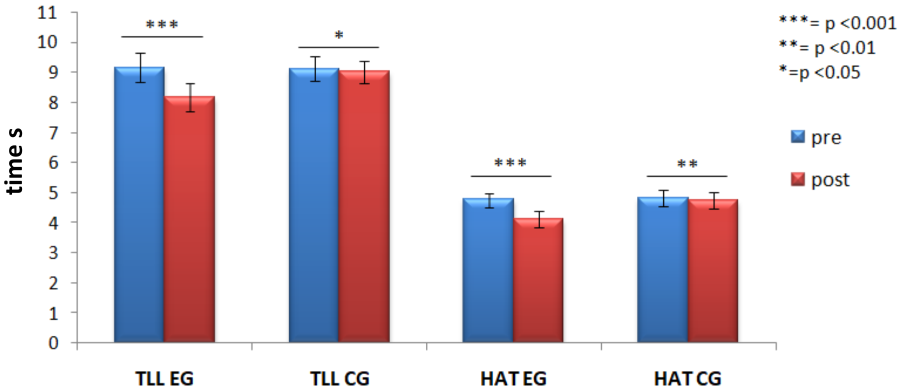
Test	**Group**	**Phase of Test**	**X ±SD**	**DX post-pre ±SD**	**95% CI Lower Upper**	**t**	**p**	**d**	**ip%**

RTsLL (s)	EG (n=12)	pre	.611 ±.027	-.091 ±.007	.086	44. 0	.000*	12. 7	-14.9
		post	.520 ±.032		.096				
	CG (n=12)	pre	.618 ±.027	-.028 ±.009	.022	11. 0	.000*	3.2	-4.5
		post	.590 ±.029		.033				
TLL (s)	EG (n=12)	pre	9.153 ±.489	-.983 ±.079	.932	43.1	.000*	12. 4	-10.7
		post	8.170 ±.473		1.033				
	CG (n=12)	pre	9.103 ±.444	-.093 ±.115	.019	2.8	.018*	.8	-1.0
		post	9.010 ±.376		.166				
HAT (s)	EG (n=12)	pre	4.796 ±.183	-.677 ±.123	.598	19. 0	.000*	5.5	-14.1
		post	4.119 .286		.755				
	CG (n=12)	pre	4.805 ±.284	-.057 ±.06	.018	3.3	.008*	1.0	-1.2
		post	4.748 ±.268		.095				

RTsLL—Reaction Time Lower Limb; TLL—Tapping Lower Limb; HAT—Hexagon Agility Test; X ± DS—mean ± standard deviation; DX—difference of means; 95% C.I., interval of confidence with lower and upper levels; t—Student's t-test; p—statistical level of probability; d—Cohen 's effect size; * Significant at $p<0.05$; ip%— increase percentage; T—value of t at the significance level of 0.05 = 2.074.



Graph 1. Mean scores (± standard deviations) for Reaction Time Experimental and Control Group (RTsLL, EG; RTsLL, CG). * indicates significant change (post–pre) when using T Test , p <.05.



Graph 2. Mean scores (± standard deviations) for Tapping Lower Limb in Experimental and Control Group (TLL, EG; TLL ,CG), Hexagon Agility Test in Experimental and Control Group (HAT, EG; HAT, CG) . * indicates significant change (post–pre) when using T Test , p <0.05.

5. Discussion

Our main hypothesis is whether the training method with the use of technological tools is more effective than the traditional method. Among the multiple coordination factors, the ability to react in the shortest time with rapid body movements and agility in changes of direction are important qualities for performance in many sports disciplines (Jakovljevic et al., 2012). Unfortunately there are still few studies investigating the effects of a training program with the use of action perception sensors on motor skills in advanced athletes. In our study, the initial score show that the EG and CG start from the same initial level, in fact the average times in the pre-test are similar in each trial (Graph 1 and Graph 2). After 6 weeks of training both groups improved in all tests but with different margins in favor of EG. In fact, in the post-test the mean times of the EG were clearly lower, therefore better than those of the CG in each trial, respectively DX = -.07 s, p<.05 in the RTsLL, DX = -.84 s, p<.05 in the TLL and DX = -.629, p<.05 in the HAT. A first consideration is that a 6-week pre-season athletic training program still produces positive effects on reaction times, agility and quickness. It has been shown that physical activity and sport can be related to improved motor reaction times (Okubo et al., 2017; Walton et al., 2018) and agility. In 6 weeks, the EG obtained performance improvements equal to -14.9% in RTsLL, -10.7% in TLL and -14.1% in HAT respectively with very high effect power values (q > 0.8)(Table 2). The improvement in the RTsLL test is significant as reaction time is the first important step in performing quickness and agility tasks more effectively (Sheppard & Young, 2006). Bidil S. et al (Bidil et al., 2021) demonstrated that 8 weeks of training with action perception light sensors improved visual reaction times on international bagminton athletes. The EG also achieved significant improvements in tests of agility (HAT) and quickness (TLL) these results are also in line with other research even if they used different study designs. Galpin et al (Galpin et al., 2008) demonstrated that 4 weeks of foot quickness and reaction training with a visual sensor platform produced improvements in overall agility in unagility-trained, but active men and women . A 3-week basketball training program improved agility and quickness motor performance in young players (Silvestri et al., 2023).

6. Conclusion

In conclusion, we can state that a 6-week training program with the use of exercises that make use of technological devices for light perception at predefined/random intervals (perception-action) improved the cognitive and physical performance in female volleyball players, resulting more effective than traditional training. The use of technological tools such as action perception light sensors offer a fun and motivating environment which, through the variability of the practice, contributes to the improvement of motor skills in the subjects. Through the software that manages the lights, athletes are able to have immediate feedback during training, such as timing detection and the number of errors, which pushes the athlete to work on personal limits and therefore greater performance. The aspects of the intensity of the load, the related motivational methodological aspects and the perception of competence can represent a field of investigation for future studies. The exercises with the sensors, if properly studied on the basis of the performance model of the chosen discipline and with suitable methodologies, in the same amount of time, manage to obtain better results in some contexts than training with traditional exercises. This aspect is very relevant for those involved in physical preparation as in the pre-championship phase there is generally a need to raise the level of physical abilities of the athletes in a short time. The use of action perception light sensors should therefore be known and used by coaches or physical trainers as a supplement to the usual training methodologies to maximize sporting performance. However, further research is still needed, especially to confirm the effects in the medium and long term, with numerically more representative samples for both genders, and on more sports disciplines. In addition, other tests in controlled environments, such as in the laboratory for more accurate measurements of physiological parameters, should be integrated to help design standardized test protocols that make use of light sensors.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

References

Appelbaum, L. G., & Erickson, G. (2018). Sports vision training: A review of the state-of-the-art in digital training techniques. *International Review of Sport and Exercise Psychology*, *11*(1), 160–189.

Baechle, T. R., Earle, R. W., & Allerheiligen, W. B. (1994). Strength training and spotting techniques. *Essentials of Strength Training and Conditioning*, 345–400.

Beekhuizen, K. S., Davis, M. D., Kolber, M. J., & Cheng, M.-S. S. (2009). Test-retest reliability and minimal detectable change of the hexagon agility test. *The Journal of Strength & Conditioning Research*, *23*(7), 2167–2171.

Bidil, S., Arslan, B., Bozkurt, K., Duzova, S. C., ÖRS, B. S., Onarici Gungor, E., & Şimsek, D. (2021). Investigation of the Effect of Badminton-Specific 8 Week Reaction Training on Visual-Motor Reaction Time and Visual Cognitive Dual Task. *Turkiye Klinikleri Journal of Sports Sciences*, *13*(1).

BlazePod™. (2023). *No Title*. https://blazepod.eu/

Bloomfield, J., Ackland, T., Elliott, B., & Ricketts, P. (1994). Applied anatomy and biomechanics in sport. In *Not available*.

Chronojump system, Barcellona. (n.d.). www.chronojump.org

Fitlight System. (2022). https://www.fitlighttraining.com/

Florkiewicz, B., Fogtman, S., Kszak-Krzyżanowska, A., & Zwierko, T. (2014). The ability to maintain attention during visuomotor task performance in handball players and non-athletes. *Central European Journal of Sport Sciences and Medicine*, *7*, 99–106.

Gabbett, T., & Georgieff, B. (2007). Physiological and anthropometric characteristics of Australian junior national, state, and novice volleyball players. *The Journal of Strength & Conditioning Research*, *21*(3), 902–908.

Galpin, A. J., Li, Y., Lohnes, C. A., & Schilling, B. K. (2008). A 4-week choice foot speed and choice reaction training program improves agility in previously non-agility trained, but active men and women. *The Journal of Strength & Conditioning Research*, *22*(6), 1901–1907.

Grosser, M., & Renner, T. (2007). *Schnelligkeitstraining*. BLV-Buchverl.

Jakovljevic, S. T., Karalejic, M. S., Pajic, Z. B., Macura, M. M., & Erculj, F. F. (2012). Speed and agility of 12-and 14-year-old elite male basketball players. *The Journal of Strength & Conditioning Research*, *26*(9), 2453–2459.

Jayaswal, A. A. (2016). Comparison between auditory and visual simple reaction times and its relationship with gender in 1st year MBBS students of Jawaharlal Nehru Medical College, Bhagalpur, Bihar. *International Journal of*

Medical Research and Review, *4*(7), 1228–1232.
Jensen, A. R. (2006). *Clocking the mind: Mental chronometry and individual differences*. Elsevier.
Johnson, B. L., & Nelson, J. K. (1969). *Practical measurements for evaluation in physical education.*
Keogh, J. W. L., Weber, C. L., & Dalton, C. T. (2003). Evaluation of anthropometric, physiological, and skill-related tests for talent identification in female field hockey. *Canadian Journal of Applied Physiology*, *28*(3), 397–409.
Kuan, Y. M., Zuhairi, N. A., Manan, F. A., Knight, V. F., & Omar, R. (2018). Visual reaction time and visual anticipation time between athletes and non-athletes. *Malaysian Journal of Public Health Medicine*, *1*, 135–141.
Lidor, R., & Ziv, G. (2010). Physical and physiological attributes of female volleyball players-a review. *The Journal of Strength & Conditioning Research*, *24*(7), 1963–1973.
Miller, J. M., Hilbert, S. C., & Brown, L. E. (2001). Speed, quickness, and agility training for senior tennis players. *Strength & Conditioning Journal*, *23*(5), 62.
Mroczek, D. (2007). Changes in psychomotor reactions and the activity of certain physiological indices of volleyball players. *Studies in Physical Culture & Tourism*, *14*.
Nuri, L., Shadmehr, A., Ghotbi, N., & Attarbashi Moghadam, B. (2013). Reaction time and anticipatory skill of athletes in open and closed skill-dominated sport. *European Journal of Sport Science*, *13*(5), 431–436.
Okubo, Y., Schoene, D., & Lord, S. R. (2017). Step training improves reaction time, gait and balance and reduces falls in older people: a systematic review and meta-analysis. *British Journal of Sports Medicine*, *51*(7), 586–593.
ReactionX. (2022). https://www.ql-sport.com/intelligent-response-training-lamp.html
Reigal, R. E., Barrero, S., Martín, I., Morales-Sánchez, V., Juárez-Ruiz de Mier, R., & Hernández-Mendo, A. (2019). Relationships between reaction time, selective attention, physical activity, and physical fitness in children. *Frontiers in Psychology*, 2278.
Sawilowsky, S. S. (2009). New effect size rules of thumb. *Journal of Modern Applied Statistical Methods*, *8*(2), 26.
Sekulic, D., Pehar, M., Krolo, A., Spasic, M., Uljevic, O., Calleja-González, J., & Sattler, T. (2017). Evaluation of basketball-specific agility: applicability of preplanned and nonplanned agility performances for differentiating playing positions and playing levels. *The Journal of Strength & Conditioning Research*, *31*(8), 2278–2288.
Sheppard, J. M., & Young, W. B. (2006). Agility literature review: Classifications, training and testing. *Journal of Sports Sciences*, *24*(9), 919–932.
Silva, C. D., & Tumelero, S. (2007). Comparação física e de resposta ao

treinamento para atletas da categoria infanto-juvenil em funções específicas no voleibol. *Lecturas: Educación Física y Deportes*, *107*, 40.
Silvestri, F., Campanella, M., Bertollo, M., Albuquerque, M. R., Bonavolontà, V., Perroni, F., Baldari, C., Guidetti, L., & Curzi, D. (2023). Acute Effects of Fitlight Training on Cognitive-Motor Processes in Young Basketball Players. *International Journal of Environmental Research and Public Health*, *20*(1), 817.
Walton, C. C., Keegan, R. J., Martin, M., & Hallock, H. (2018). The potential role for cognitive training in sport: more research needed. *Frontiers in Psychology*, *9*, 1121.
Wilke, J., Vogel, O., & Ungricht, S. (2020). Can we measure perceptual-cognitive function during athletic movement? A framework for and reliability of a sports-related testing battery. *Physical Therapy in Sport*, *43*, 120–126.

Date: 10 aprile 2023
Author: Nicola Mancini
Phone: +39 3284121547
Mail: nicola.mancini@unifg.it