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Original Article

The paradigm of the manifestation level of proprioception in triple jumpers - case studies

RAPOTAN ANDREEA[1], MIHĂILESCU LILIANA[2], MIHAI ILIE[3]
[1,2] Doctoral School of Sports Science and Physical Education, University of Pitesti, ROMANIA
[3] Department of Physical Education and Sports, University of Pitesti, ROMANIA

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Abstract:
The triple jump is one of the most demanding and complex events in athletics due to its physical and technical requirements. The successful practice of the triple jump event does not only involve the development of the main determinant motor qualities in the performance equation and the continuous improvement of the specific technique, but also the education/development of some perceptual-cognitive components, which isn`t explored enough in the specialized studies. Proprioceptive information plays a very important role in cognitive actions, body image, control of body movements and its segments, balance and coordination, helping into increasing performance. The aim of the research is to determine the paradigm of the level of manifestation of proprioception, that includes balance and agility, in the top national athletes in the triple jump. For this reaserch we performed a series of tests such as Agility test, Static Balance test, Dynamic Vertical Balance test, March in place with open eyes 20 seconds test, March in place with closed eyes 20 seconds test, on a number of eight national top athletes, 1 woman and 7 men, from 16 to 33 years old, specialized in the triple jump event. The results collected can provide a diagnosis of the level at which these skills are manifested in the case of the athletes specialized in triple jump, and an objective premise in the methodological direction of their training, by highlighting the positive and negative aspects, of each, and the differences between them in the lower and upper limbs, aspects that play an important role in individualizing their preparation for better performance in this complex athletic event both technically and physically. For this research we used measuring and evaluation equipment from the laboratory of the Research Center for Human Performance, University of Pitesti, logistics that provides objective information in the direction of our research: Sensamove Mini Board balance platform, Optojump Next motion analysis system and system Witty Sem.
Key Words*:* **triple jump, proprioception, agility, balance**

Introduction

Practicing the triple jump involves the development/education of a wide range of conditional skills/motor qualities (speed, strength, endurance), coordination (dexterity, balance, ambidexterity, elasticity, flexibility, mobility, suppleness) and psychomotor skills (space orientation, laterality, ideomotority) in various forms of their combinations. Joseph L. Rogers believes that "those who practice triple jump must have an above average ability to sprint and perform jumps while having strong muscles and developed motor skills." (Rogers J.L., 2004, p.155)

Agility does not manifest itself independently but is closed related to other qualities such as reaction and in which power plays a decisive role. (Bompa T., Carrera M., 2015, p.111) This can be viewed/analyzed from two perspectives, the first one is related to the ability to change direction and the second one in combination with perceptual-cognitive aspects. In the triple jump, the development of agility requires the improvement of perceptual-cognitive skills. (Haff G., Triplett N.T., 2016, p.533)

The way in which proprioception creates a pattern of the position of the body and its segments in moments of dynamic and static stress is a basic level of psychomotor coordination. (Olteanu A., Lupu V., 2000, p.15) Proprioception allows us to perceive movement, position in space, and the actions of our own body. (Taylor J.L., 2009, para.1) This is defined as the conscious or unconscious ability of an individual to perceive the position of his body and joints relative to space, performed in response of the neuromuscular system to sensory information, or in Benefits Of The Proprioceptive Training In Recovery After Knee Sprain-Theoretical Grounds (2016) as the ability of the body to help us react consciously or unconsciously to stimulation through movement, to place ourselves in space, to feel body posture, an ability that develops over time. (Andrews J.R., Harrelson G.L., Wilk K.E., 2012, para.1, Gidu D., Oltean A., 2016, para.9)

Proprioception is a "complex of sensations that include the perception of movement, joint position, muscle strength, and exertion, which are received by the skin, muscles, and joints.". (Taylor J.L., 2009, para.1) In combination with other "senses" it allows the individual to position objects in relation to their own body and contributes to the creation of the body image and plays an important role in movement control in sports that

Corresponding Author: RAPOTAN ANDREEA, E-mail: rapotan_andreea@yahoo.com

require good coordination. "Vision plays an integral role in the successful execution of interceptive actions by providing both exteroceptive and proprioceptive information for movement control.". (Davids K., Savelsbergh G., Bennett S.J., Van der Kamp J., 2002, p.90; Taylor J.L., 2009, para.1)

In our study we considered all the opinions of the specialists who researched the specific aspects of this ability and we shared the opinion that "Proprioception is an internal subconscious mechanism, it is observable and measurable, and can be changed permanently or temporarily, and its recovery takes time, the easiest way is training.". (Gidu D., Oltean A., 2016, para.15)

"Proprioceptive training improves joint positioning and includes exercises that normalize cortico-spinal excitability (skill and strength exercises), neural adaptation strategies (afferent feedback training, imaginary movements, contralateral education)". (Hagiu B.A., 2014, p. 254) Although proprioception is much more present in interceptive sports games, where the action and position of the players or the ball are constantly changing, it can be "trained" in athletics, in the triple jump contributing to the body image, body position during the exercises, contributing to the development of coordination, balance, thus streamlining the execution technique and implicitly improving the performance.

The aim of this research is to identify the level of manifestation of proprioceptive capacity, which includes both agility and balance in the case of triple jumpers.

Material & methods

Participants

In the research we had 8 athletes (7 boys, 1 girl) specialized in the triple jump, with different ages, from 16 to 33 years old.

Procedure/Test protocol/Skill test trial/Measure/Instruments

The drive technology was based on the use of devices and equipment for measuring and testing balance (Sensamove Sensabalance Miniboard balance platform, Optojump Next - optical motion analysis system) and agility (Witty Sem intelligent traffic lights), components of research logistics from the laboratory of the Research Center for Human Performance, Pitesti.

During the application of the drive design, the subjects performed the following tests: Agility test, Static balance test, Dynamic - vertical balance test, March in Place eyes open test, Mach in Place eyes closed test.

Agility measurement

To measure the level of agility, we used 4 Witty Sem intelligent traffic lights through which we could visualize light signals (of different colors: red, blue, green) emitted alternative, at an interval of one second between them. The devices were placed in line, with a distance of 30 cm between them, 50 cm away from the athlete and positioned on a tripod at a height of 1.50 m. The way of working involved adopting a sitting position on one leg (first on the right, then on the left), the other leg being bent at the knee joint and kept parallel to the supporting leg. The task of the athletes was to react as quickly as possible to the green symbol emitted by the traffic lights (10 stimuli) by performing arm movements to determine the alternation of visual stimuli.

Balance measurement

The determination of balance was oriented towards two components, static balance and dynamic balance. The measurement of the expression of the static balance was made from unipodal support using the Sensamove Sensabalance Mini Board platform, the way of working being first on the right leg and then on the left leg. The measurement protocol involved positioning the athletes on the platform as follows: sitting on the platform, on one leg, with the knee slightly bent, the other leg bent at the knee joint, knees at the same level, arms crossed with hands on shoulders. From this position, the athletes had as their motor task the structural neuro-motor reorganization by maintaining in a fixed position a visual stimulus on the computer monitor, for 20 seconds.

The dynamic balance was measured using the Sensamove Sensabalance Mini platform and the Optojump Next optical motion analysis system. When using the Sensamove Sesnsabalance balance platform, the initial working position was similar to that of the static balance test, with unipodal support. To measure the level of dynamic balance, athletes had to move the visual stimulus from the computer monitor antero-posteriorly (forward-backward) inside a delimited area.

The application of the March in Place eyes open and Mach in Place eyes closed tests involved a run with the knees up, on the spot, for 20 seconds, inside a space delimited by the segments of the Optojump Next system.

Data collection and analysis / Statistical analysis

The software specific to each measuring device allows the download of data collected in Excel files, after which we could process and present for the agility test, parameters such as total working time, motor response time for each impulse, arithmetic mean, for static balance test and dynamically vertical performance, deviations, percentage left or right of space, and for the test march in place the contact time on each leg, the flight time, or the used area.

Results

The parameters recorded following the application of the Agility Test can be found in Tables 1 and 2.

Table 1. The results from agility test on the right foot

Name	Gen.	Categ.	Total Time(s)	S.l. 1 (s)	S.l. 2 (s)	S.l. 3 (s)	S.l. 4 (s)	S.l. 5 (s)	S.l. 6 (s)	S.l. 7 (s)	S.l. 8 (s)	S.l. 9 (s)	S.l. 10 (s)	Mean (s)
B.C.	F	S	9,68	1,35	0,14	0,71	0,98	1,06	0,77	1,08	0,87	1,18	1,54	0,97
T.A.	M	S	11,88	0,78	1,22	1,65	1,08	1,15	1,07	1,24	1,26	1,39	1,04	1,19
P.M.	M	U23	7,58	0,69	1,36	0,28	0,14	1,27	0,11	0,97	0,9	0,98	0,88	0,76
O.L.	M	U23	9,63	1,39	0,95	1,3	0,93	0,81	0,82	0,81	0,86	0,79	0,97	0,96
C.D.	M	U23	7,78	1,04	0,66	0,74	0,18	0,57	0,68	0,89	1,09	1,22	0,71	0,78
S.D.	M	U23	9,49	0,87	0,97	0,86	0,97	0,71	1,24	1	0,83	1,14	0,9	0,95
C.B.	M	U23	12,12	1,22	1,07	1,38	1,02	1,36	1,09	0,99	1,37	1,53	1,09	1,21
B.R.	M	U18	18,74	0,46	2,9	1,72	3,14	2,58	1,81	1,62	1,83	1,43	1,25	1,87

Legend: S - senior; U23 – under 23; U18 – under 18; S_{1-10} – response time.

Table 2. The results from agility test on the left foot

Name	Gen.	Categ.	Total Time (s)	S.l. 1 (s)	S.l. 2 (s)	S.l. 3 (s)	S.l. 4 (s)	S.l. 5 (s)	S.l. 6 (s)	S.l. 7 (s)	S.l. 8 (s)	S.l. 9 (s)	S.l. 10 (s)	Mean (s)
B.C.	F	S	11,71	2,12	1,08	0,67	0,85	1,11	1,04	1,25	0,78	1,34	1,47	1,17
T.A.	M	S	11,35	1,12	1,08	1,23	1,23	1,48	1,11	1,05	1,12	1,02	0,91	1,14
P.M.	M	U23	11,26	0,86	0,75	2,71	1,02	0,85	0,91	1,03	1,16	0,91	1,06	1,13
O.L.	M	U23	13,08	1,38	1,09	2,19	0,87	0,84	2,32	1,16	1,56	0,66	1,01	1,31
C.D.	M	U23	9,17	1,59	0,44	0,59	0,76	1,29	0,89	0,52	0,27	0,81	2,01	0,92
S.D.	M	U23	11,93	1,58	1,01	1,42	0,92	1,15	0,87	0,76	1,4	1,75	1,07	1,19
C.B.	M	U23	12,07	1,36	1,49	1,27	1,35	1,18	1,09	0,99	1,37	1,53	1,09	1,27
B.R.	M	U18	13,92	1,66	1,48	1,3	1,18	1,1	1,21	0,95	0,87	2,57	1,6	1,39

Legend: S - senior; U23 – under 23; U18 – under 18; S_{1-10} – response time.

The analysis of the results took into account the best and the weakest time, at the level of arithmetic mean, the differences of the athletes between the left and the right foot in relation to the leg used at the first step or the third step of the motor structure of the triple jump

The difference between the values of the arithmetic mean in the case of the athlete B.C. is 0.2 sec, expressing close values between the left and right foot. The best time is obtained on the right leg which is also the leg used on the board. T.A. has small differences between the times of the two legs. The difference between the averages is 0.05 sec, but the times obtained by it for the ten stimuli are between 0.78-1.65 sec on the right leg and 0.91 and 1.48 sec on the left leg. P.M. gets the best time between athletes on the right leg (7.58 sec) and the best value of the arithmetic mean (0.76 sec) for the 10 signals. At the same time, he manages to obtain the best reaction time among all subjects (0.9 sec). On the left foot, however, we notice major differences.

The total time is 11.26 sec, with an arithmetic mean value of 1.13 sec, with values between 0.75 sec and 2.71 sec. It should be noted that the right foot, the one on which the athlete recorded better values, is also the foot used for the first step. O.L. obtains a value of the arithmetic mean of 0.96 sec, with times between 0.79 - 0.97 sec, but also 2 times of over 1 sec. On the left leg it records a mean value of 1.31 sec and 2 times over 2 sec. The difference in the mean of the two legs is 0.35 sec in favor of the foot used for the third step. C.D. has the second best time on the right leg (7.78 sec) and the second best value of the arithmetic mean (0.78 sec) among the tested athletes. At the same time, he records the best time (9.17 sec) and the best value of the arithmetic mean on the left foot (0.92 sec). In the case of this athlete, we notice a greater constancy of the motor response adaptation to the appearance of the visual stimulus, the difference between the value of the mean of the response on the right and the left leg being 0.14 sec. Although in the case of this athlete the results obtained are very good on both legs, the best time is recorded on the leg used for the first step.

The holder of the third time in the test performed on the right leg., S.D., obtains a weaker time on the left leg, the athlete using the right leg for the first step. The value of the arithmetic mean on the right leg is 0.95 sec, and on the left it is 1.19 sec, with a difference of 0.24 sec. And in the case of the athlete C.B. the difference between the mean is a small one (0.06 sec), which demonstrates a constancy of the work on both legs, but as in the case of the previous athlete, the times obtained for the ten stimuli have high values, being between 0.99 - 1.53 sec on the right leg and 0.99-1.53 on the left leg. The longest time belongs to B.R. with a time of 18.74 sec on the right leg and 13.92 sec on the left leg. The difference between the averages is 0.48 sec. It also has the longest measured time from the appearance of the light signal to the emission of the motor response (3.14 sec). For this athlete, the best time is not obtained on the leg used in the first step.

Balance tests

The results recorded in the static balance test are shown in Tables 3 and 4, and for the vertical dynamic balance test in Tables 5 and 6.

Table 3. The results of the static balance test on the right foot

Name	Gender	Category	Performance (%)	Avg. forward deviation (º)	Avg. backward deviation (º)	Avg.left deviation (º)	Avg. right deviation (º)
B.C.	F	S	84	1,19	-1,23	-0,46	0,92
T.A.	M	S	82	2,06	-1,03	-0,6	1,04
P.M.	M	U23	87	0,97	-0,78	-0,74	0,87
O.L.	M	U23	63	3,04	-1,51	-1,99	1,84
C.D.	M	U23	75	1,17	-2,20	-0,73	1,55
S.D.	M	U23	80	2,01	-1,40	-1,16	1,08
C.B.	M	U23	78	0,86	-1,69	-0,76	1,34
B.R.	M	U18	80	1,58	-1,38	-0,73	1,24

Table 4. The results of the static balance test on the left foot

Name	Gender	Category	Performance (%)	Avg. forward deviation (º)	Avg. backward deviation (º)	Avg. left deviation (º)	Avg. right deviation (º)
B.C.	F	S	84	0,75	-0,7	-1,42	0,6
T.A.	M	S	83	1,04	-1,08	-1,28	0,16
P.M.	M	U23	85	0,99	-1,18	-0,89	0,66
O.L.	M	U23	73	2,00	-1,37	-1,8	0,68
C.D.	M	U23	84	0,96	-1,14	-1,17	0,7
S.D.	M	U23	88	0,75	-1,03	-0,58	0,73
C.B.	M	U23	79	1,95	-1,37	-1,08	0,98
B.R.	M	U18	73	2,3	-1,69	-1,46	1,28

B.C. achieves the same performance score on both legs, respectively 84%, although the differences between the deviations recorded on the two legs are relatively large. The difference between the forward average deviation is 0.44º, the difference between the backward average deviation is 0.53º, the difference of the left average deviation is 0.96º, and the difference between the right average deviation is 0.32º.

Another athlete with small differences in performance is T.A., with a performance of 82% on the right leg, according to Table 3, and 83% on the left. The difference between the forward average deviation is 1.02º, between the average backward deviation is 0.05º, between the average left deviation 0.68º, and the average right deviation is 0.88º, which results in an asymmetry between the right and left foot, despite the recorded performance.

In the static balance test on the right leg, athlete P.M. obtains the best result with a performance of 87%, expressed in figure 1, being the athlete with the smallest deviations recorded on the right leg, both forward-backward and left-right according to table 3, the right being the take-off leg. The differences between the right and the left leg are small. The difference between the average forward deviation is 0.02º, the difference between the average backward deviation is 0.4º, the difference between the left average deviation is 0.15º, and the difference between the average right deviation of the legs is 0.21º, the performance on the left leg being marked with 85%, which shows small differences between the right and left foot. O.L. obtains the weakest performance, 63% and 73%, but also big differences between deviations, the largest being 1.16º, and for this athlete we notice an asymmetry between the left and right foot, as well as an inability to maintain balance. Better performance is recorded on the left foot which is used in the first step.

For C.D. we notice both differences between the level of performance on each leg, respectively 75% and 84%, but also between the deviations recorded. The largest is 1.06º. For this athlete, in addition to the asymmetries between the right and the left leg, we can see a lower ability to maintain balance on the right leg, compared to the left, which is also the leg used on the board. With an 80% performance on the right leg, athlete S.D. records a value of 88% on the left foot, as shown in Table 4, the largest of the athletes tested, the deviations recorded on the left foot being much smaller compared to the right.

And athlete C.B. obtains similar performance values, respectively 78% and 79%, but the differences between the average deviations being also in his case quite large. The average forward difference is 1.09º, the average backward is 0.32º, the left average is 0.32º, and the average right deviation is 0.36º.

Athlete B.R. achieves modest performance on both legs, the differences between the deviations not so big, 0.72º the average front deviation, 0.31º the average rear deviation, 0.73º the left deviation and 0.04º the right deviation.

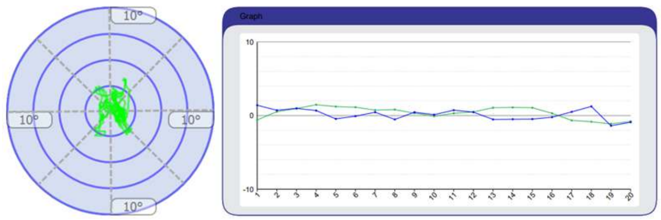

Figure 1 Results of P.M.`s right foot at balance test

Vertical dynamic balance

Table 5. The results for vertical dynamic balance on the right foot

Name	Gender	Category	Performance (%)	Left space (%)	Right space (%)	Avg. forward deviation (º)	Avg. backward deviation (º)	Avg. left deviation (º)	Avg. right deviation (º)
B.C.	F	S	97	42	56	3,66	-3,89	-0,79	1,09
T.A.	M	S	93	48	46	5,35	-5,45	-0,62	0,89
P.M.	M	U23	98	30	68	5,01	-3,81	-0,72	0,92
O.L.	M	U23	89	46	43	4,95	-3,23	-1,25	1,16
C.D.	M	U23	89	28	62	2,81	-2,95	-0,68	1,33
S.D.	M	U23	95	38	58	3,56	-3,6	-1,2	0,98
C.B.	M	U23	92	35	56	4,45	-5,03	-0,68	1
B.R.	M	U18	87	28	59	4,78	-3,29	-0,8	1,36

Table 6. The results for vertical dynamic balance on the left foot

Name	Gender	Category	Performance (%)	Left space (%)	Right space (%)	Avg. forward deviation (º)	Avg. backward deviation (º)	Avg. left deviation (º)	Avg. right deviation (º)
B.C.	F	S	79	70	8	5,22	-3,5	-1,85	0,45
T.A.	M	S	87	61	26	6,55	-5,6	-1,02	0,47
P.M.	M	U23	96	40	56	4,18	-3,86	-0,74	0,89
O.L.	M	U23	86	53	32	4,48	-3,45	-1,72	0,81
C.D.	M	U23	89	62	27	3,79	-3,68	-1,39	0,9
S.D.	M	U23	90	71	20	5,11	-4,78	-1,16	0,58
C.B.	M	U23	92	66	27	4,31	-3,97	-1,22	0,63
B.R.	M	U18	92	51	41	4,66	-3,47	-1,08	0,94

For B.C., the differences between the performance values are considerable. She has a very good value on the right leg, 97%, which is also the leg used for the first step, and on the left only 79%, as shown in Figure 3. Also, according to Table 6, for the left leg the deviations show a tendency to keep the foot on the right side of the space of only 8%.

T.A. also obtains high performance values, as well as small differences between them, being marked with 93% and 87%. Although he records the highest values of the deviations between the tested athletes, the differences between the right and the left foot are relatively small, the average difference before is 1.2º, back 0.15º, left 0.4º and right 0.42º. And for this athlete, the best values are obtained on the leg used on the first step.

As in the previous test, the athlete with the best performances recorded in the dynamic balance test is P.M., marked with 98% on the right leg (figure 2) and 96% on the left leg. The differences between the average deviations are also small: 0.83º forward deviation, 0.05º backward deviation, 0.02º left deviation, 0.03º right deviation.

O.L. records average values of the performances, but similar between the two legs, respectively 89% and 86%, and the differences between the deviations do not exceed 0.47º.

Athlete C.D. is noted with the same performance on both legs, respectively 89%, an average value of balance. Although the deviations are not very big, the differences between the left and right foot are considerable.

S.D. also obtains small differences between performances, being marked with 95% and 90%, resulting in a good ability to maintain balance, as well as good joint mobility, but the differences between the deviations confirm an asymmetry between the right and left foot.

C.B. achieves the same performance on both legs, 92%, and the differences between the recorded deviations are not noticeable, expressing a symmetry between the legs, as well as a good mobility of the ankle joint.

The small difference between the performances is also obtained by the youngest athlete of the group, B.R., registered with 87% on the right leg, resulting in a lower mobility of which is also the leg used in the hop, and 92% on the left leg. The differences between the average deviations on the two legs are also small, the largest recorded being 0.42º.

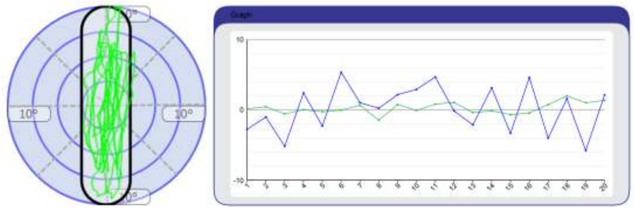

Figure 2. The results of P.M. at dynamic vertical balance test on the left foot

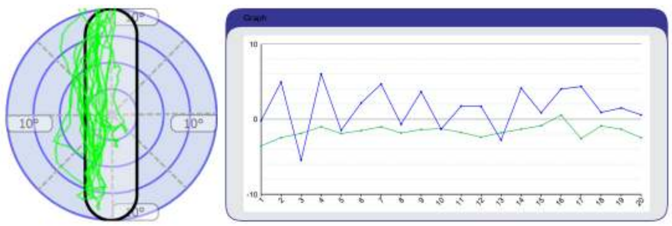

Figure 3. The results of B.C. at dynamic vertical balance test on the left foot

March in place

The results of the March in place test with eyes open and eyes closed are shown in Tables 7 and 8.

Table 7. The results of March in place with eyes open

Name	Gender	Categ.	Cont.t L (sec)	Cont.t R (sec)	Flight t L (sec)	Flight t R (sec)	Tend. L (cm)	Tend. R (cm)	Used area L (cm)	Used area R (cm)
B.C.	F	S	0,176	0,24	0,456	0,447	0,2	0,1	10,7	11,1
T.A.	M	S	0,189	0,2	0,35	0,35	0,2	0,2	13,5	13,8
P.M.	M	U23	0,144	0,157	0,4	0,384	0	-0,3	13,7	13,7
O.L.	M	U23	0,173	0,177	0,423	0,416	0,3	0	14,1	14,7
C.D.	M	U23	0,186	0,181	0,446	0,453	0,2	-0,2	17,9	18,2
S.D.	M	U23	0,171	0,179	0,473	0,458	0,4	0,1	19,1	19,9
C.B.	M	U23	0,158	0,226	0,373	0,376	-0,2	0,1	12,3	12
B.R.	M	U18	0,207	0,205	0,427	0,419	0	-0,2	15,9	15,9

Table 8. The results of March in place with eyes closed

Name	Gender	Categ.	Cont.t L (sec)	Cont.t R (sec)	Flight t L (sec)	Flight t R (sec)	Tend. L (cm)	Tend. R (cm)	Used area L (cm)	Used area R (cm)
B.C.	F	S	0,188	0,193	0,45	0,44	0,9	0,6	12,8	14,5
T.A.	M	S	0,187	0,212	0,358	0,344	-0,5	-0,5	14,7	14,3
P.M.	M	U23	0,207	0,209	0,414	0,417	-0,3	-0,5	18,4	17,8
O.L.	M	U23	0,184	0,231	0,439	0,419	0,2	0	16	16,5
C.D.	M	U23	0,19	0,196	0,443	0,429	0,4	0,1	17,1	17,7
S.D.	M	U23	0,191	0,198	0,437	0,45	1,3	0,5	19,5	21,7
C.B.	M	U23	0,178	0,181	0,382	0,392	0,6	0,3	11,7	12,6
B.R.	M	U18	0,229	0,225	0,44	0,441	0,2	-0,1	17,3	17,8

For B.C. the differences between the two tests were not large. In the case of the open-eye test, the differences were small. The difference between the contact time is 0.064 sec and the area used is 0.4 cm. In the closed-eye test, the difference between the contact time on the left and the right leg was 0.005 sec, and the difference between the flight time was 0.01 sec. The difference between the surface used on the two legs was 1.7 cm. The results indicate a symmetrical use of the feet in both tests, the only difference being the movement over a larger area in the closed-eye test.

The smallest differences between the open-eye test and the closed-eye test are recorded by the athlete T.A., who in the case of contact times on the left foot has a difference of 0.002 sec, and on the right foot a difference of 0.012 sec. The difference between the surface used on the left leg in the two tests is 1.2 cm, and on the right is 0.5 cm, this athlete is not having major asymmetries between the left and right foot and not too large deviations.

For P.M., although there are small differences between the left and the right leg in both tests, the differences between the open-eyed and the closed-eyed test are greater. The difference between the contact time in the two tests is 0.063 sec on the left leg and 0.052 sec on the right leg. The contact times recorded in the closed-eye test, as well as the area used on both legs, are among the longest measured, but nevertheless the times obtained in the open-eye test are the shortest, resulting in the fact that this athlete encounters difficulties in executing the test with eyes closed.

Athlete O.L. in the case of the open-eye test has a difference in contact time of 0.6 cm, and in the closed-eye test a difference of 0.047 sec in the contact time between the left and right foot and the difference between the area used on the two legs is 0.5 cm. For this athlete no major differences were reported between the two tests nor between the left and right foot.

C.D. does not measure large differences between the contact times in the case of the two tests or between the left and right foot, and the used area, although quite large compared to other athletes, does not show large differences between the left and right foot.

S.D. has also small differences between the used area in both tests, but according to Table 7 and Table 8 is the athlete who moves the most of those tested. The area used on the right leg in the closed-eye test is 21.7 cm. The difference between the two tests at the time of contact on the left leg is 0.02 sec and on the right leg is 0.019 sec. It results that this athlete has an inability to remain in place during the execution.

And for C.B. there were very small differences in the two tests, both in terms of contact time, flight time and surface used.

B.R. records the longest contact times on both legs in both tests among the tested athletes, but the differences between the legs in both tests are small, the difference between the area used in both tests is also small.

Dicussion

Due to the fact that the subjects of our research have different ages, and their number does not allow us to express opinions on the trend of the level of skills assessed by us, their paradigm at group level, our research is based on case studies, analysis and interpretation of results.

Similar tests have been performed in articles such as Determinants of Reactive Agility in Tests with Different Demands on Sensory and Motor Components in Handball Players (2021), also with the help of the Witty Sem system, which included 4 photocells placed in line at a distance of 10 cm between them, and the participants had to respond to 20 stimuli by reacting with the dominant hand to the photocells with green symbol, which aimed at the relationship and its contribution along with the reaction speed, muscle strength to the Y-shaped agility test to handball players. (Horníková H., Jele M., Zemková E., 2021, p.3)

In the paper Determination of balance parameters as physical training factors in Athletics (2018), the same tests are used to analyze the balance and mobility of the ankle joint of an athlete specialized in 100m, 200m and long jump, using the same equipment. (Mihăilescu L. , Mihai I., Georgescu F., 2018, para.1) He achieved a performance of 87% in the static balance test on the right leg and 89% on the left foot, being classified as good results, while in the case of the vertical dynamic balance test, the performance on the right leg is 78%, and on the left one, of 93%. (Mihăilescu L., Mihai I., Georgescu F., 2018, para.5-6)

In the documentation performed for this research, we did not find such measurements applied to the jumpers in the triple jump.

Conclusions

The results of the study highlight the individual characteristics of the subjects, characteristics that, if known by coaches, can be objective landmarks in the methodological direction of their training.

Following this research, we made a diagnosis of the paradigm of the level of manifestation of the proprioceptive capacity of each of the research subjects, highlighting the positive aspects, the shortcomings of each, as well as the differences between them in the lower and upper limbs, important aspects in individualizing their preparation for improving performance in this complex athletic event both technically and physically.

The results of each athlete are objective indicators on the basis of which it is possible to intervene better, for the education/development of the psychomotor components evaluated in the research, which facilitates the improvement of the performance in the competition test.

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