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A Novel Method to Measure Dual-Task Capacity in Young Football Players: A Preliminary Study

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Context: When deciding to return to sport, in the literature, evaluations based on physical abilities have usually been used. However, in the current literature, we have been urged to use more than physical performance evaluations. Classical dual-task testing methods do not simulate in-game loads and cannot sufficiently measure football players' dual-task capacity.

Objective: To create a dual-task test that would simulate football players' in-game situations and measure their capacity.

Design: Cross-sectional study.

Setting: Football pitch.

Patients or Other Participants: Twenty-two football players (age = 17.37 ± 0.52 years) who played in a professional club (U19, elite league) were recruited for our study.

Intervention(s): A novel dual-task test with questions containing scenarios from a football game to cognitively load players while they are performing a modified *t* test.

Main Outcome Measure(s): After the warmup period, participants attended 4 tests in random order: juggling (foot), speed dribbling, long passing, and novel dual-task tests.

Results: No significant relationship was found between physical performance parameters and dual-task parameters (all $P > .05$). A significant increase was found in the completion time of the modified *t* test when performed under the dual-task condition ($Z = -7.568$, $P < .001$). The increase in completion time was 2.14 ± 1.29 seconds. This duration difference was calculated as 22.79% ± 14.58%, as dual-task cost.

Conclusions: Our test provides a new method to measure athletes' dual-task capacity, which is not related to physical performance and cannot be measured with current tests. This test also showed players with lower dual-task ability could not keep up their performance under dual-task conditions, such as passing a ball to a teammate when being pressed by an opponent. Players with good dual-task ability could maintain their performance (were affected only up to 10%); players with poor dual-task ability could not maintain their performance and were affected by up to 50% (with a mean of 22.79%).

Key Words: soccer, athletic performance, psychomotor performance

Key Points

- The novel dual-task test provides a new method to measure athletes' dual-task capacity, which is not related to physical performance and cannot be measured with current tests.
- Players with poor dual-task ability could not maintain their performance and were affected by up to 50% (with a mean of 22.79%).
- The test can be adjusted by modifying the complexity of in-game scenarios, which allows the novel dual-task test to be tailored to the level of the football players.

When deciding to return to sport, in the literature, evaluations based on physical abilities, such as speed, agility, strength, and power, have usually been used.[1–4] However, in the current literature, we have been urged to use more than physical performance evaluations.[5–7] Factors such as time, self-trust, and fear of movement are considered in the current return-to-sport criteria, especially after anterior cruciate ligament (ACL) injuries.[5–8] Although these psychological factors and numerous physical performance parameters are measured after a physical injury (eg, an ACL tear), the cognitive effect or load of this injury and its effect on motor planning has not been thoroughly investigated.

Dual-process theory accepts that automatic and controlled processing systems control human behavior and is the underlying theory on a human's ability to perform multiple tasks simultaneously.[9,10] Especially in rehabilitation settings, dual-task testing is commonly used in neurology literature.[11–13] This testing procedure is executed by cognitively loading the subject while performing a motor task and measuring how much the motor task is affected by cognitive loading.[14–16] Performing multiple tasks is in the nature of football players, as they must find an opening or a teammate to pass on the field while dribbling with the ball and analyzing the opponent players' movements.

In the current literature, classical dual-task methods, such as counting backward from 100 while walking over obstacles, have been used to measure athletes' capacity.[17–21] Like other traditional test methods, classical dual-task testing methods do not simulate in-game loads and cannot sufficiently measure football players' dual-task capacity. The purpose of our study was to create a dual-task test that would simulate football

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players' in-game situations and measure their capacity. We wanted this task to not be too physically challenging, which would cause the test to be performance dependent: players with lower physical performance would score lower on the test, and when they increased their physical performance, their test scores would improve. We hypothesized that the dual-task test would be able to measure football players' dual-task capacity, and this capacity would not be related to physical performance parameters.

METHODS

This study was approved by the Hacettepe University Ethical Committee with approval number GO 21/481. After receiving ethical approval, we sent invitations to football youth teams in the local area and measured the players of the teams that accepted. The measurements were performed at 10 AM on the club's football field. On the measurement day, the players did not train and only performed their routine warmup protocol. After the warmup protocol, players performed the tests in a randomized order (by whichever they wanted to start first, with equal players distributed to all tests) on their football club's field. The novel dual-task test was repeated for 10 players after a week for reliability analysis.

Twenty-six football players were on the team, 4 of whom reported having difficulty seeing the material and therefore were excluded from the study. Twenty-two healthy male football players (age = 17.37 ± 0.52 years, 19/3 right/left dominancy) who played in a professional club (U19 team in an elite league) were recruited for our study. The player position distribution was 6 defenders, 12 midfielders, and 4 forwards. We did not include goalkeepers, as they do not engage in the scenarios that we prepared. We only included football players who had been playing professionally for at least 3 years. Our exclusion criteria included any health-related problem that could affect attending regular training or neurological disorders.

On the day of the measurement, players gave informed consent. After the routine warmup period, participants attended 4 tests in random order: juggling (foot), speed dribbling, and long passing (which are performance tests) and novel dual-task tests.

The juggling (foot) test measures coordination skills. To perform the test, the players dropped the ball by hand to the foot and tried to juggle it as many times as possible without letting it touch the ground. The test was normally repeated 3 times, but no further attempts were made if a player could juggle 25 times in the attempt. The test was repeated for each foot separately.[22]

The speed dribbling test measures speed and coordinated dribbling skills. This test is prepared by placing 2 poles on the starting line (first). Six poles are used to form a triangle by placing 3 poles on the same line (second) 5 m ahead from the starting line (base of the triangle), 2 poles on the same line (third) in the middle 2.5 m ahead from the second line, and 1 pole 2.5 m ahead from the third line (tip of the triangle). A block is placed 10 m ahead from the last pole, with another block placed 8 m ahead from the first block. Finally, 2 poles are placed on the finishing line 20 m ahead from the last block. To perform the test, the player stood ready behind the start line and, on the "go" signal, dribbled toward the right corner pole of the triangle, around the pole from the outside to the inside of the second pole, from the outside around the pole, and continued the set order until

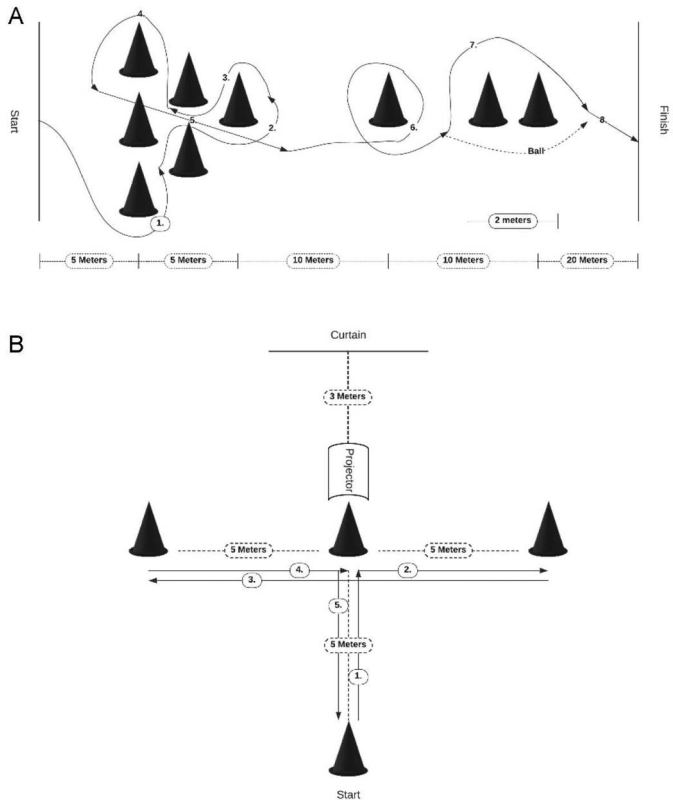

Figure. Speed dribbling and novel dual-task tests.

the player faced the finishing line again (right after turning around the left corner of the triangle). He then dribbled toward the first block and circled around it, dribbled toward the second block, played the ball from the left side, ran around the right side of the block, and collected the ball, sprinting through the final gate and stopping the ball. The examiner recorded the time with a chronometer (Keenso PC3830A) from the "go" signal until the player stopped the ball with his foot (Figure A).[22]

The long passing test measures passing accuracy and shooting power over a long distance. To perform the test, the player attempted to pass the ball to a circle with a radius of 2 m that was 36 m away and located within a 10-m by 10-m square zone. The player was allowed to do a trial first, then performed 5 passes. If the ball landed in the circle or touched its circumference, the player received 3 points; if the ball landed in the square, the player received 1 point.[22]

The novel dual-task test consisted of motor and cognitive tasks. For the motor task of the test, we used a modified version of the *t* test.[23] On the football field, we placed a projector curtain (Codegen, TX-18, 180 cm by 180 cm) and a starting cone 8 m apart. From the starting cone, we set a middle cone 5 m away (3 m from the curtain) and placed another 2 cones 5 m to the right and left of the middle cone (essentially, we reduced the length of the *t* from 10 m to 5 m). The original *t* test was modified so that players could see the curtain easily during the whole testing process. The projector (BenQ, MH550) was placed 1 m away from the middle cone toward the curtain, and the computer was on the side of the testing area with the researcher behind it (Figure B).

For the cognitive task of the novel test, we prepared and took pictures of scenarios from a football game. In these scenarios, the camera was placed to simulate the perspective of

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the player who had the ball, and teammates and opponents were on the field. Depending on the picture, passing positions could consist of 3 versus 2, 4 versus 3, and 5 versus 3 (number of opponents versus teammates) scenarios, and long passing scenarios could consist of 6 versus 5, 7 versus 6, and 8 versus 7. In these scenarios, at least 1 player raised his hand to show he was available to receive the ball.

At the beginning of the novel dual-task test, players did a trial run. For the first test, players performed the modified *t* tests while dribbling the ball, and the timing was recorded. In the second test, players performed the modified *t* test while dribbling, and the researcher projected the scenarios and asked players to recite the squad number of the player who was available to receive the ball. The timing was measured with a chronometer (Keenso PC3830A), and mistakes (saying the wrong squad number or losing control of the ball) were noted. The primary criterion was the difference in the modified *t* test time. The secondary criteria were the mistakes of the players. Dual-task cost was calculated with the following formula:

$$([\text{Dual-task test time} - \text{Modified } t \text{ test time}]/\text{Modified } t \text{ test time}) \times 100.^{17}$$

Statistical analyses were performed using SPSS-26 (IBM Corp, released 2019, IBM SPSS Statistics for Windows, Version 26.0). Normal distribution was assessed using visual (histograms and probability plots) and analytical methods (Kolmogorov-Simirnov and Shapiro-Wilk tests). Our data were not normally distributed; the paired-samples *t* test was used to analyze the difference between the 2 measurements. Changes in parameters were calculated by subtracting the normal test from the dual-task condition. A value of $P < .05$ was accepted as statistically significant. Spearmen correlation was used to analyze the relation between the dual-task test and performance parameters. Hopkins' scale was used to define correlations as *small* (<0.3), *moderate* (0.3–0.5), *large* (0.5–0.7), *very large* (0.7–0.9), and *nearly perfect* (>0.9).[24] The intraclass correlation coefficients ($ICC_{agreement}$) and 95% CIs were calculated with a 2-way random effects model, single-rater properties.[25] An ICC of 0.40–0.59 was considered as *fair*, 0.60–0.74 as *good*, and >0.75 as *excellent*.[26]

RESULTS

Twenty-two healthy football players (mean age = 17.37 ± 0.52 years, height = 174.93 ± 6.32 cm, mass = 71.21 ± 5.2 kg, body mass index = 23.27 ± 1.09 kg/m^2) participated in our study. The performance test results are presented in the Table. No significant relationship was found between the physical performance parameters and dual-task parameters (all $P > .05$).

A significant increase was found in the completion time of the modified *t* test when performed under the dual-task condition ($Z = -7.568$, $P < .001$). The slowing time was the duration difference between modified *t* tests with and without cognitive loading, which was the novel dual-task test. The difference was 2.14 ± 1.29 seconds, and the dual-task cost was calculated as 22.79% ± 14.58%. When test-retest analysis was performed, our novel dual-task test had an ICC of 0.98 with a 95% CI of 0.82 to 0.99.

DISCUSSION

In the current literature, classical dual-task testing methods do not simulate in-game loads and cannot sufficiently measure football players' dual-task capacity. Therefore, we aimed to create a dual-task test that would simulate football players' in-game situations and measure their capacity. As we hypothesized, the dual-task test was able to measure football players' dual-task capacity and showed that adding dual-task loading decreased performance during dribbling. We also found that the physical performance parameters did not affect the dual-task capacity. This showed that dual-task loading (ie, deciding which player to pass the ball while dribbling) can decrease a player's physical performance regardless of the player's performance capacity.

The dual-task test we developed uses scenarios from the football game to cognitively load football players and measures the effect of the load on the modified *t* test, which requires dribbling, change of direction, and ball control. In the literature, researchers have used different methods to measure dual-task capacity in football players and athletes. In more health-related studies, Laurin et al used juggling as motor performance and subtracting from 100 as cognitive loading[10]; Howell et al and Oldham et al used walking as motor performance and spelling a 5-letter word backward, subtracting by 6's or 7's from a randomly presented 2-digit number, or reciting the months in reverse order starting from a randomly chosen month as cognitive loading[27,28]; and Howell et al again used the timed up-and-go test as motor performance and subtracting by 6's or 7's from a randomly presented 2-digit number as cognitive loading.[29] In more performance-related studies, Fleddermann et al used block jumps as motor performance in a study consisting of elite volleyball players and videos and pictures of an opponent attacking as cognitive loading[30]; Van Biesen et al used balance on a leg as performance in a study consisting of athletes and a multiple object tracking test as cognitive loading[31]; and Akbari et al used the drop vertical jump as motor performance and stationary ball for header as cognitive loading.[32] Most testing methods require either too little motor performance from the football player (ie, walking) or loads with a cognitive loading that is not sport specific (ie, subtracting 7's from 99). Even in the study by Akbari et al, which is closest to actual football scenarios, stationary ball for header is not a cognitive challenge on an elite football player level.[32] Our test design both puts a high demand on motor performance (high speed dribbling with the change of direction) and uses an actual game-based cognitive load, which allows us to measure a player's real potential.

In our study, football players' physical performance was not related to the dual-task testing. In dual-task testing, as we primarily measure motor function, we wanted to see if the football players with better physical performance could produce better dual-task results. In theory, players with better physical performance would have less cognitive load while performing the motor task, resulting in having more cognitive capacity to process the dual-task condition. As we showed in our study, this was not the case, and our players' physical performance did not affect dual-task capacity. Moreover, our test showed that players with good dual-task ability could maintain their performance (were affected only up to 10%); players with poor dual-task ability could not maintain their performance and were affected by up to 50% (with a mean of 22.79%). The new dual-task testing method measures dual-task capacity, which is not related to physical performance.

In football, players are required to understand and keep up with the constant changing of their environment (opponents'

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Table. Descriptives and Correlations

Parameters	Mean ± SD (95% CI)		Performance Parameters					Novel Dual-Task Parameters			
			Juggling Right	Juggling Left	Juggling Total	Speed Dribbling	Long Passing	Modified *t* Test	Novel Dual-Task Test	Slowing[b]	Dual-Task Cost
Performance parameters											
Juggling, count[a]											
Right	25 (5–25)	*r*	1	–0.183	0.446	–0.304	–0.170	–0.263	–0.184	0.153	0.188
		P	0	.454	.056	.206	.486	.308	.480	.557	.47
Left	19 (3–25)	*r*	NA	1	0.787[c]	–0.032	–0.157	0.082	0.165	–0.072	–0.001
		P	NA	0	.000	.898	.522	.753	.527	.784	.996
Total	38 (17–50)	*r*	NA	NA	1	–0.200	–0.309	–0.131	0.010	0.036	0.123
		P	NA	NA	0	.412	.198	.616	.969	.892	.637
Speed dribbling, s	18.2 ± 1.76 (17.4, 19)	*r*	NA	NA	NA	1	–0.056	0.103	–0.135	–0.487[c]	–0.296
		P	NA	NA	NA	0	.805	.667	.572	.034	.205
Long passing, score	8.48 ± 2.17 (7.45, 9.3)	*r*	NA	NA	NA	NA	1	0.137	0.027	–0.143	–0.208
		P	NA	NA	NA	NA	0	.554	.906	.547	.367
Novel dual-task parameters											
Modified *t* test, s	9.66 ± 1.02 (9.25, 10.2)	*r*	NA	NA	NA	NA	NA	1	0.594[c]	–0.339	–0.382
		P	NA	NA	NA	NA	NA	0	.005	.144	.087
Novel dual-task test, s	11.79 ± 1.41 (11.2, 12.5)	*r*	NA	NA	NA	NA	NA	NA	1	0.476[c]	0.408
		P	NA	NA	NA	NA	NA	NA	0	.034	.066
Slowing, s	2.14 ± 1.29 (1.55, 2.72)	*r*	NA	NA	NA	NA	NA	NA	NA	1	0.977[c]
		P	NA	NA	NA	NA	NA	NA	NA	0	.00
Dual-task cost, %	22.79 ± 14.58 (16.1, 29.4)	*r*	NA	NA	NA	NA	NA	NA	NA	NA	1
		P	NA	NA	NA	NA	NA	NA	NA	NA	0

Abbreviation: NA, not applicable.
[a] Values are given as median (minimum–maximum).
[b] Slowing is the time difference between the novel dual-task and modified *t* tests.
[c] $P < .05$.

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and teammates' movements [including speed, direction, and intent] and movement of the ball) and make plans accordingly. This ability is related to the dual-task capacity of the player, and when that capacity is low or decreased, players are not able to process the input in time, resulting in a delayed reaction (eg, a player attempting a last-second cut, side-step, or turn maneuver may keep his planted foot stationary while his body turns), which can result in an ACL injury. Not only in the case of last-second decision-making but also as the game goes on, the player's brain gets fatigued, causing his dual-task capacity to decrease. This leads him to miss or react late to the input, potentially leading to injury. Considering these possibilities, periodically measuring and training players to increase their dual-task capacity would not only improve their physical performance but also might help them notice any problematic position earlier, enabling them to react before getting injured and thereby preventing possible injuries.

After lower extremity injuries, we clinically measure players' physical performance to see whether the players are physically ready to return to sport. We also use psychological tests to measure kinesiophobia and readiness, assessing how much this injury affected the player's psychology. We even deny a player the opportunity to return to sport if he scores poorly on these tests. However, we are not measuring how this psychological effect of the injury affects physical performance and why. Furthermore, in some cases, players can be in denial (or too proud to admit to themselves) of the extent of this psychological problem, which would not be detected by the aforementioned tests (although a player may have a fear of jumping too high, he could say that, "I am confident in my knee that it will not give way by playing my sport"). However, in reality, even though a player might score well on physical tests (especially return-to-sport tests), he could do it while focusing on his knee rather than focusing on the task itself. This is not feasible in real-game situations, in which the demand on the player's dual-task capacity is too high to allow sparing any focus on his injured legs. Therefore, measuring dual-task capacity and seeing how it is affected might be a clue to determine the scale of this effect, and clinicians could focus on restoring or improving the dual-task capacity to prevent these problems.

A few limitations to our study existed. Measuring football players during the season was problematic due to their busy schedules; therefore, our sample pool was limited. As a result of this limited sample pool, we could not divide the players based on their positions. Also, 4 players reported difficulties seeing our test materials when we were describing the tests. Although we did not anticipate this problem, we excluded them from the study.

CONCLUSIONS

In football, athletes are evaluated regularly for routine physical performance measurements and health controls. Our test provides a new method to measure athletes' dual-task capacity, which is not related to physical performance and cannot be measured with current tests. This test also showed players with lower dual-task ability could not keep up their performance under dual-task conditions, such as passing a ball to a teammate when being pressed by an opponent. With further studies in which authors investigate the relationship between a dual-task test and recovery from injuries, this test may take the place of routine return-to-sport evaluations and performance testing. An advantage of our proposed test is that the examiner can adjust the difficulty of the novel dual-task test by modifying the complexity of in-game scenarios projected on the curtain. This flexibility allows the examiner to adjust the test based on the age, football history, and expertise level of the players in their football team.

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