Effect of two incremental intensity field tests on wellness indices, recovery state, and physical enjoyment in soccer players

O. SELMI[1,2], D.E. LEVITT[3], A. MUSCELLA[4], N. OUERGHI[1], I. ISSAOUI[1], W. ABASSI[1], L. HILL[5], T. ROSEMANN[6], A. BOUASSIDA[1], B. KNECHTLE[6]

[1]Research Unit, Sportive Performance and Physical Rehabilitation, High Institute of Sports and Physical Education of Kef, University of Jendouba, Kef, Tunisia
[2]High Institute of Sports and Physical Education, Ksar Said, University of Manouba, Tunis, Tunisia
[3]Department of Physiology, School of Medicine, Louisiana State University Health Sciences Center, New Orleans, LA, USA
[4]Department of Biological and Environmental Science and Technologies (DiSTeBA), University of Salento, Lecce, Italy
[5]Division of Gastroenterology and Nutrition, Department of Pediatrics, McMaster University, Hamilton, ON, Canada
[6]Institute of Primary Care, University of Zurich, Zurich, Switzerland

Abstract. – OBJECTIVE: Competitive athletes must undergo fitness testing to monitor athlete progress and to create appropriate, progressive training programs. However, fitness testing adds to training stress; therefore, impacts of testing on wellness and recovery must be considered in test selection. This study investigated the effects of two incremental field tests [VAMEVAL test (T-VAM) and 20-m maximum shuttle test (20-m MST)] on wellness, total quality of recovery (TQR) and physical enjoyment (PE) in competitive soccer players.

SUBJECTS AND METHODS: Twenty-two soccer players (20.9±1.5 years) completed two T-VAM and two 20-m MST in a randomized order on separate days with a 1-week interval between tests. TQR and wellness indices (sleep, fatigue, stress and muscle soreness) measures were collected before and 24 hours after each test. Heart rate (HR) was continuously monitored during each test. Rating of perceived exertion (RPE) and PE were assessed after each test.

RESULTS: T-VAM resulted in higher PE, TQR and wellness scores than 20-m MST ($p<0.05$). T-VAM and 20-m MST resulted in similar HR and maximal aerobic speed. For T-VAM, TQR was correlated ($p<0.01$) with RPE and wellness indices. For 20-m MST, TQR was correlated ($p<0.01$) with wellness indices. HRmax and RPE were not correlated with wellness indices, TQR or PE.

CONCLUSIONS: Overall, T-VAM and 20-m MST produced similar aerobic fitness testing results, but athletes responded more favorably to T-VAM. Coaches can use T-VAM for evaluating aerobic fitness while maximizing well-being and physical enjoyment among soccer players.

Introduction

Soccer matches rely heavily on aerobic metabolism while requiring bursts of high-intensity effort. Several tests, including maximal aerobic field tests and incremental intensity tests, have been used to evaluate aerobic fitness in athletes[1,2]. Two commonly administered incremental intensity field tests are the "Vitesse aérobie maximale" or maximum aerobic speed evaluation (T-VAM)[1] and the 20-m maximum shuttle test (20-m MST)[2]. These tests can estimate athletes' maximal oxygen uptake (VO_{2max}) and measure maximum aerobic speed (MAS) and maximum heart rate (HRmax), allowing coaches to monitor progress and to calibrate the intensity of the training program[3].

Intense aerobic training can positively[4] and negatively[5,6] affect status and well-being. Psychometric status can be influenced by training load, fatigue accumulation, balance between training and recovery, physical conditioning, and training modality[7]. Selmi et al[6] reported that intensified aerobic exercise at 110% of MAS negatively affected mood state in soccer players. In contrast, overall findings indicate that intensified exercise training (>100% MAS) may result in more satisfaction, positive mood state, mo-

Corresponding Author: Beat Knechtle, MD; e-mail: beat.knechtle@hispeed.ch

tivation, and greater physical enjoyment[6,8]. Previous studies[4,7,9] indicated that physical enjoyment was associated with exercise modality but was not related to recovery state, fatigue level or training load. Furthermore, several studies[10-12] have reported that poorer perceived well-being and lack of recovery may negatively affect sport performance.

Maximal aerobic training evokes physiological responses that contribute to changes in wellness and recovery states[11]. For that reason, markers of psychometric status associated with maximal aerobic exercise have received much attention in recent years[10,12,13]. Researchers have utilized various subjective scales, including the rating of perceived exertion (RPE) scale, the total quality of recovery (TQR) scale and the Hooper questionnaire measuring well-being indices [sleep quality, fatigue level, stress and delayed-onset muscular soreness (DOMS)] to examine perceived exertion[14], recovery state[15], and wellness[12,16], respectively. These tools are effective in detecting early signs of fatigue and insufficient recovery. Furthermore, they assess wellness and mood to aid in optimizing training[12,13]. In fact, poor recovery state, negative perceived wellness (stress, fatigue level, sleep quality and DOMS) and mood state during training are associated with poorer performance[7,12]. However, to the best of our knowledge, the impact of commonly used incremental intensity tests on psychometric status in soccer players has not been examined. Thus, the study had two main aims: first, to investigate perceived effort, physical enjoyment, and wellness in response to two commonly used incremental intensity field tests of aerobic fitness (T-VAM and 20-m MST), and secondly, to examine relationships between parameters measured during these tests (HRmax, MAS, RPE and physical enjoyment) and psychometric indices (sleep, stress, fatigue, DOMS and TQR). We hypothesized that T-VAM would result in more positive psychometric status and recovery than 20-m MST in soccer players, and that psychometric status would not be influenced by parameters measured during these tests. Results will assist coaches in determining how the administration of selected incremental intensity field tests may affect athlete recovery, well-being, and psychometric status.

Subjects and Methods

Participants

Twenty-two amateur male players from the same soccer team in Tunisia took part in the study (age: 20.9±1.5 years, height: 1.78±0.10 m, body mass: 73.7±3.9 kg, body fat: 11.6±2.6%, training age: 8.6±1.2 years, M±SD). For their regular training, all players completed 6-7 training sessions per week (9-10 hours/week) spread over 6 days, with 1 day of rest each week. Goalkeepers were excluded from the investigation because they did not participate in the same physical training program as the other players. All players reported being injury-free at the beginning of the study. The investigation was conducted according to the Declaration of Helsinki and the protocol was fully approved by the by the Local Ethics Committee Research Unit (UR 2019-95). All the participants provided written informed consent after a detailed explanation of the aims, procedures, and risks involved in the study.

Procedures

The study was carried out between March and April of 2019. Before beginning the experimental sessions, measurements of height and body mass were obtained (OHAUS, Florham Park, NJ), and body fat percentage was calculated from skinfold thickness measurements according to validated methods[17]. Participants were familiarized with the wellness scales (sleep, stress, fatigue and DOMS), RPE scale, TQR scale and physical activity enjoyment scale (PACES) as well as the incremental intensity field tests (T-VAM and 20-m MST) prior to the beginning of the study.

Four testing sessions were performed, each separated by a 1-week interval. At each testing session, the players were split into two groups, with 11 players performing the T-VAM and the other 11 performing the 20-m MST in a randomized order. In total, each player performed the T-VAM twice and the 20-m MST twice. TQR and wellness indices (perceived ratings of sleep quality during the preceding night, fatigue, stress and DOMS) scales were completed before and 24 hours after each test.

Participants were asked to complete the scales based on the preceding 24 hours. HR was continuously monitored during each test. RPE and PACES were recorded after each test.

All participants refrained from strenuous exercise for 48 hours (since their previous soccer practice) prior to testing, and all measurements were taken at the same time of day (between 9:00 AM and 10:30 AM) to limit the potential effects of circadian variation on physiological variables. The weather conditions on test days were comparable (no hard winds, no extreme cold or warmth

and no rain; described in detail in the subsequent "Field Testing" section), and the field conditions were good. Moreover, all participants were asked to avoid eating for 3 hours before and to not drink any caffeinated beverages for 8 hours before each test. To avoid any influence of stretching on performance, participants performed only dynamic stretching (e.g., no static stretching or myofascial release) in the 24 hours before the experimental sessions[12]. The same fitness trainer collected data for each testing session.

Rating of Perceived Exertion

Immediately after each test, participants were asked to rate their mean perceived exertion using the RPE scale (Borg CR-10 scale)[14] as a measure of subjective intensity. The RPE scale ranged from 0-10 where 0 represented "not at all" and 10 represented "extremely hard/almost maximal" exertion in response to the standardized question: "how hard did you exert yourself during exercise?". This method has been used in previous studies[18] as an indicator of athletes' perceived exertion.

Sleep, Stress, Fatigue and Muscle Soreness Monitoring

Wellness variables were assessed using the Hooper questionnaire[16] which consists of the four following items: (i) sleep quality, (ii) stress, (iii) delayed-onset muscle soreness (DOMS) (especially "heavy legs"), and (iv) fatigue level. The Hooper questionnaire was completed on the morning of each testing session and the following morning (i.e., 24 hours later) before any physical training. Each participant was asked to complete ratings of wellness indices (quality of sleep, fatigue, stress, and DOMS) since the preceding training session. Each item was measured separately using subjective rating scales ranging from 1 to 7 points where 1 indicated "very very low" (fatigue, stress, DOMS) or "good" (quality of sleep during the preceding night) and 7 indicated "very very high" (fatigue, stress, DOMS) or "bad" (quality of sleep). The sum of these four items was used to calculate the Hooper score (HS). A higher HS indicates a more negative wellness state. The Hooper questionnaire has been used in previous studies[7,10,18] as an indicator of athletes' perceived wellness.

Total Quality Recovery

Recovery state was assessed using the total quality recovery (TQR) scale[18]. The TQR scale was completed on the morning of each testing ses-

sion and the following morning (i.e., 24 hours later) before any physical training and was reflective of the response to the preceding training day. Each player was asked "What is your condition now?" and responded using a scale from 6 to 20 points, where 6 indicated "not recovered at all" and 20 indicated "completely recovered"[15]. The TQR has been used in previous studies as an indicator of athletes' perceived recovery[12].

Physical Activity Enjoyment

After completion of each field test, participants performed a 5-min dynamic cool-down, then were seated for 5 min and subsequently completed the PACES questionnaire[19]. Ten minutes of rest between the end of the field test and the beginning of the PACES questionnaire ensured focus by mitigating effects of residual fatigue on the athletes' scores[7]. Participants were asked to rate how they felt at the moment about the physical activity they had been doing. The inventory contains 18 items rated on a 7-point scale [e.g., (1) "It's very pleasant" to (7) "It's not fun at all"]. A total of 11 items were reverse scored. An overall physical activity enjoyment score was generated by summing the individual item scores, which yielded a possible total score of 18 to 126. Higher PACES scores reflect greater levels of enjoyment. Following completion of all four experimental sessions, participants were asked to indicate which incremental intensity field test they preferred.

Field Testing

All subjects performed two incremental intensity protocols to exhaustion two times each in a randomized order (T-VAM and 20-m MST). Each test took place following a rest day and was conducted at the beginning of that day's training session. The participants were asked to perform at maximum effort during each test. The T-VAM[1] and the 20-m MST[20] are incremental intensity field tests used to evaluate aerobic fitness. These tests were completed on four separate occasions between 9:00 and 10:30 AM in ambient conditions averaging $17 \pm 1°C$ and $69 \pm 2\%$ relative humidity. The T-VAM was performed on a 200-m outdoor running track. Players ran guided by a pre-programmed auditory signal (i.e., beep) and ten cones placed every 20 m around the track. The test began with a running speed of 8 km/h with consecutive speed increases of 0.5 km/h each minute until exhaustion. To achieve speed increases, beeps became closer together in time with the same running distance (i.e., 20 m between cones)

required. The 20-m MST was performed on a natural grass field. For this test, participants ran back and forth on a 20-m course and were required to touch the 20-m line at the same time that an auditory signal was emitted from a pre-recorded tape. The test began with a running speed of 8.5 km/h with consecutive speed increases of 0.5 km/h each minute until exhaustion.

During each test, participants adjusted their running speed to reach the cones placed at 20-m intervals by the time the auditory signal was emitted. Each test ended when a participant was unable to reach the next cone by the time of the beep on two consecutive occasions or felt that they could not complete the stage. The running speed of the last fully completed stage was retained as the maximal aerobic speed (MAS).

Heart Rate

HR was continuously monitored throughout each experimental session (T-VAM and 20-m MST) by HR monitors (Polar Team Sport System, Polar-Electro OY, Kempele, Finland). HR was averaged and recorded at 5-s intervals. The highest heart rate (HR) value measured during each test was recorded as the HRmax. To reduce HR recording error, all players were regularly asked to check their HR monitors during the test.

Statistical Analysis

The normality of data was verified using the Kolmogorov-Smirnov test. Each testing protocol (T-VAM and 20-m MST) was performed twice. The two resulting MAS, HRmax, RPE and PACES scores for each test were averaged for analysis by student's paired t-test. Magnitude of change expressed as Cohen's d was employed to give a rigorous judgment of effect size between T-VAM and 20-m MST[21]. The scales of magnitude were considered trivial: d ≤ 0.20; small: 0.20 < d ≤ 0.50; medium: 0.50 < d ≤ 0.80; and large: d > 0.80[22]. For psychometric status, a two-way repeated-measures Analysis of Variance (ANOVA) was used to examine the effect of the "test" (T-VAM or 20-m MST), "time" (pre- and post- test) and their interaction (test x time) on the scores of the TQR and wellness indices (sleep quality, stress, fatigue, DOMS and HS). When a significant interaction effect was observed, the location of the interaction was determined using a Bonferroni post-hoc test. Pearson product moment correlation coefficients were used to examine relationships between

psychometric status (collected the day following each test), and HRmax, RPE and MAS collected during test sessions. The magnitude of the correlation was expressed as trivial: r < 0.1; low: 0.1-0.3; moderate: 0.3-0.5; large: 0.5-0.7; very large: 0.7-0.9; nearly perfect > 0.9; and perfect: 1[21]. Analyses were conducted using the Statistical Package for the Social Sciences (SPSS Inc., Chicago, IL, USA) and the level of significance was set at $p < 0.05$. All data are expressed as mean ± standard deviation (SD) unless otherwise specified.

Results

All participants were able to complete all experimental sessions as prescribed.

Test Performance Measures

PACES score was significantly ($p<0.001$) greater for T-VAM than for 20-m MST (Table I). In total, 18 participants preferred T-VAM to 20-m MST, while 4 preferred 20-m MST to T-VAM. No significant differences between T-VAM and 20-m MST were observed for HRmax, MAS or RPE (Table I).

Wellness and Recovery Measures

A main effect of time was observed for sleep ($p=0.03$, $\eta_p^2=0.20$, Figure 1A), where sleep score increased post-test. A test x time interaction was observed for stress ($p=0.008$, $\eta_p^2=0.29$, Figure 1B), where the stress score was greater for 20-m MST post-test than for all other measurements. A test x time interaction was observed for fatigue ($p<0.001$, $\eta_p^2=0.51$, Figure 1C), where fatigue increased from pre- to post-test for both tests, but the increase was greater for 20-m MST. A test x time interaction was observed for DOMS ($p<0.001$, $\eta_p^2=0.58$, Figure 1D), where DOMS increased from pre- to post-test for both tests, but the increase was greater for 20-m MST. A test x time interaction was observed for HS ($p<0.001$, $\eta_p^2=0.61$, Figure 1E), where HS increased from pre- to post-test for both tests, but the increase was greater for 20-m MST. A test x time interaction was observed for TQR ($p=0.001$, $\eta_p^2=0.40$, Figure 1F), where TQR decreased from pre- to post-test for both tests, but the decrease was greater for 20-m MST.

For T-VAM (Table II), TQR was negatively correlated with stress, fatigue, DOMS, and HS. RPE was negatively correlated with stress and
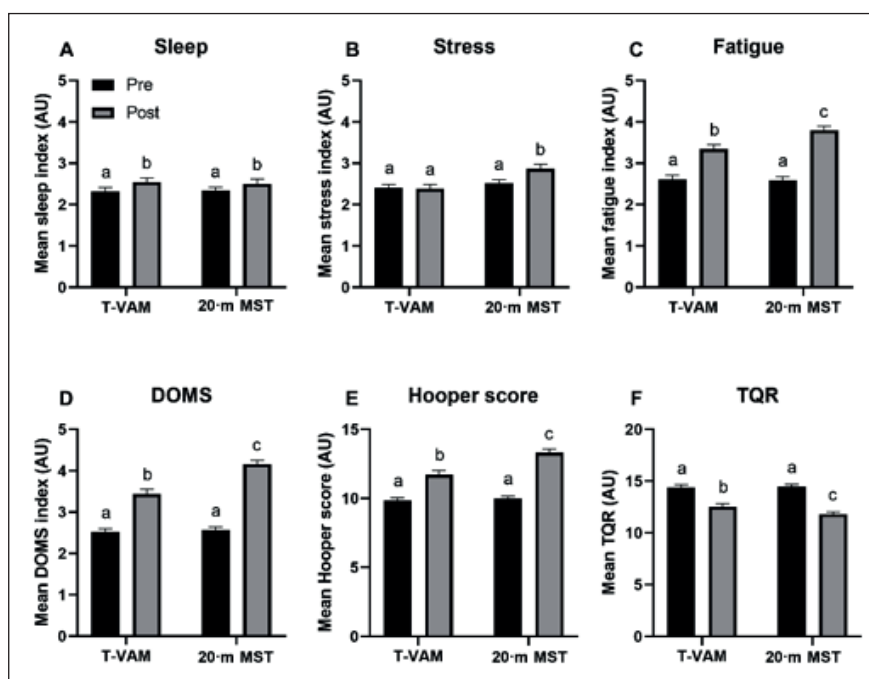
Figure I. Scores for wellness indices: sleep (**A**), stress (**B**), fatigue (**C**), delayed-onset muscle soreness (DOMS; **D**), Hooper score (**E**), and total quality of recovery (TQR; **F**) before (black bars) and 24 hours after (grey bars) the T-VAM and 20-m MST. Data were analyzed using a 2 (T-VAM *vs.* 20-m MST) x 2 (pre-test *vs.* post-test) repeated measures ANOVA. Significant interaction effects were followed by Bonferroni-corrected post-hoc pairwise comparisons. Different letters above bars indicate significant differences ($p<0.05$ for main effect in panel A, $p<0.001$ for each significant post-hoc pairwise comparison in **B-E**). N=22, M ± SEM.

positively correlated with TQR. No significant correlations were observed between ratings of stress, quality of sleep during the preceding night, DOMS, fatigue, HS, TQR and the PACES score with HRmax or MAS (Table II).

For 20-m MST (Table III), TQR was negatively correlated with stress, fatigue, DOMS, and HS. No significant correlations were observed between ratings of stress, quality of sleep during the preceding night, DOMS, fatigue, HS, TQR and PACES score with RPE, HRmax or MAS (Table III).

Discussion

The present study indicated that T-VAM resulted in greater physical enjoyment, better recovery quality and better perceived well-being compared to 20-m MST. However, T-VAM and 20-m MST resulted in similar physiological responses. Significant associations were observed between perceived recovery quality and well-being indices, but not between physiological and performance variables, physical enjoyment, and psychometric status.

Table I. Comparison of physiological variables, internal intensity and physical enjoyment between T-VAM and 20-m MST.

Variables	Field test	Mean±SD	*p*	ES	Rating
HRmax (beats·min⁻¹)	T-VAM	196.8±1.2	0.25	0.40	Small
	20-m MST	197.3±1.3			
MAS (km/h)	T-VAM	17.1±0.6	0.14	0.17	Trivial
	20-m MST	17.2±0.6			
RPE	T-VAM	8.4±0.5	0.26	0.22	Small
	20-m MST	8.5±0.4			
PACES Score	T-VAM	83.1±6.1	<0.001***	0.93	Large
	20-m MST	77.6±5.7			

Note: Comparison of physiological variables, internal intensity and physical enjoyment between T-VAM and 20-m MST. Note: HRmax: maximal heart rate; MAS: maximum aerobic speed; RPE: rating of perceived exertion; PACES: physical activity enjoyment scale; ES: Cohen's d effect size. Analyzed by Student's paired *t*-test, N=22. ***$p<0.001$ between tests, M ± SD.

Table II. Correlation between wellness indices, TQR, PACES score and physiological variables the day following T-VAM.

	Sleep	Stress	Fatigue	DOMS	HS	TQR	PACES
HRmax	0.17	-0.08	-0.11	-0.13	-0.06	0.21	-0.03
MAS	0.20	-0.23	-0.08	-0.13	-0.09	0.10	0.20
RPE	-0.13	-0.54**	-0.14	-0.34	-0.39	0.60**	0.15
TQR	-0.12	-0.49*	-0.60**	-0.68***	-0.67***	-	0.19
PACES	-0.21	-0.33	-0.07	-0.14	-0.25	0.19	-

Note: HRmax: maximal heart rate; MAS: maximum aerobic speed; RPE: rating of perceived exertion; PACES: Physical Activity Enjoyment Scale; DOMS: delayed-onset muscle soreness; HS: Hooper score, TQR: total quality recovery, *$p<0.05$, **$p<0.01$, ***$p<0.001$.

The results showed that the two aerobic field tests were similar in terms of HRmax and MAS responses. During the T-VAM and 20-m MST, HRmax values were 196.8 and 197.3 beats per minute and MAS values were 17.1 and 17.2 km/h, respectively. Both tests measure maximal aerobic speed and HR to quantify aerobic fitness; therefore, similar results suggest that differences in psychometric variables are not due to differences in test intensity. This was consistent with previous findings[23] that subjects participating in both field tests worked at similarly high intensity[3] and that these test protocols effectively measure maximal aerobic fitness. Moreover, García-Benítez et al[24] confirmed that T-VAM and 20-m MST produced similar cardiovascular responses. In the current study, subjective ratings of perceived exertion mirrored the physiological responses such that the T-VAM and 20-m MST were similarly perceived as "very hard" (RPE = 8.4 and 8.5, respectively). Together, the objective and subjective measures of test intensity confirmed that the T-VAM and 20-m MST require a similarly high level of effort and elicit very comparable results.

Physical enjoyment and positive emotional responses to sports practices are important for maintaining an athlete's motivation and performance, and the PACES is useful in such evaluations[4,7,25,26]. Our participants reported greater enjoyment for T-VAM than 20-m MST, and 18/22 participants

indicated that they preferred the T-VAM over the 20-m MST. These findings suggest that athletes enjoyed and preferred the T-VAM despite a similarly demanding physical effort. The 20-m MST requires running for many short-distance blocks and includes shuttles with increasing maximal speeds and decelerations with changes of direction. The T-VAM requires players to run in a continuous line with increasing speeds. It is possible that the setup of the T-VAM provided participants with a feeling of competence since they could visually track progress, which could explain their preference for this test over the 20-m MST. Recent studies[7,26] have shown that intense exercise subjectively rated as more enjoyable elicits more positive emotional responses, and thus could provide a basis for activity selection. While the present study showed no relationship between physical enjoyment and psychometric or physiological variables, the results of the present study can aid in the selection of incremental intensity aerobic field tests that athletes enjoy while eliciting similar test outcomes. Previous authors[4,7,9,25] have indicated that physical enjoyment was related to exercise modality and motivation but was not associated with training intensity or fatigue. For example, Oliveira et al[26] reported that athletes who are the most motivated in training sessions rate the sessions as more physically enjoyable. Motivating physical activity is an important element

Table III. Correlation between wellness indices, TQR, PACES score and physiological variables the day following 20-m MST.

	Sleep	Stress	Fatigue	DOMS	HS	TQR	PACES
HRmax	-0.22	0.11	0.39	0.33	0.20	-0.26	0.02
MAS	-0.103	-0.27	-0.19	0.33	-0.14	0.34	0.18
RPE	<0.01	-0.05	0.10	0.05	0.04	-0.16	-0.22
TQR	-0.32	-0.69***	-0.60**	-0.36	-0.85***	-	0.28
PACES	-0.37	-0.11	0.03	-0.18	-0.29	0.28	-

Note: HRmax: maximal heart rate; MAS: maximum aerobic speed; RPE: rating of perceived exertion; PACES: Physical Activity Enjoyment Scale; DOMS: delayed-onset muscle soreness; HS: Hooper score, TQR: total quality recovery, *$p<0.05$, **$p<0.01$, ***$p<0.001$.

of training, enhancing athletes' commitment and performance[25]. Therefore, physical enjoyment and mood state should be considered when selecting tests to assess athletes' aerobic fitness[7,26].

A notable finding in this study was that fatigue and DOMS were increased, and recovery was decreased after each physical test, and these responses were more pronounced after the 20-m MST than T-VAM. It is possible that the greater eccentric force requirement due to running with direction change (20-m MST) may have increased muscle damage, fatigue, and soreness in the lower limb. Previous findings[27,28] support this result, also demonstrating that high intensity (but not all-out) runs requiring direction changes may elicit higher HR, blood lactate levels, RPE[27] and might reduce the acute neuromuscular activation potential[28]. These changes may have important implications for the quality of subsequent training, and therefore, should be considered during test selection.

The present study indicated that sleep quality decreased the night after each test. It is likely that increased fatigue from training negatively affects the quality of sleep, either due to sleep disturbances or increased sleep requirements. This result is corroborated by Fullagar et al[29] who reported that significant reductions in sleep quantity and quality were associated with increased fatigue during intense training exercise. This is further supported by Rae et al[30] who demonstrated that intense bouts of exercise may reduce sleep quality.

Players also reported greater stress after the 20-m MST than after the T-VAM. This result is similar to that of Selmi et al[6] which showed that intense shuttle run training results in psychological disturbance among professional soccer players. It is possible that the lesser enjoyment of the 20-m MST combined with the greater DOMS elicited by the test synergistically increased perceived stress. The present study showed that internal intensity (RPE) during the more enjoyable T-VAM was negatively associated with stress, whereas, in the less enjoyable 20-m MST, no such relationship between RPE and stress was observed. Therefore, it appears that a multitude of factors, such as test-specific parameters (e.g., running with a change of direction), neuromuscular fatigue and task enjoyment influence psychological stress, and coaches should consider such factors during test selection.

The present investigation found a strong correlation between HS and TQR measured the day following each field test, indicating that the wellness indices and recovery quality are closely re-

lated. In contrast, this study showed no relationship between objective measures of test intensity and psychometric status measured the following day. The wellness indices and TQR are thought to be similarly sensitive to the effects of training sessions[12]. Psychometric indices measured before a training session are used to detect individual signs of fatigue before performance and to monitor the state of psycho-physiological recovery[16,18]. The objective measures of intensity (HRmax and MAS) were very similar between the two field tests administered in this study and thus do not account for the differences in recovery and psychological state. This underscores the importance of the wellness indices in providing additional insight into differential overall recovery between the two tests.

While the findings of the present study are useful in aiding coaches in selection of incremental intensity aerobic field tests, the present study also presents some limitations. The sample size was relatively small, and thus there may have been insufficient power for detection of some effects. Furthermore, the participants in the present study were soccer players, thereby limiting the generalizability of the results to athletes involved in different sports. Biological measurements such as lactate and cortisol would be useful to measure in response to these tests because they would provide additional insight into associated physiological demands. The test sessions were conducted during the competitive phase, where coaches seek to maintain maximal performance capability. It would be useful to conduct further studies during other periods of the sports season. Moreover, while the training load and the physical demands during the training sessions were known, it was not possible to control or monitor any extra activities that participants engaged in outside of the study and their structured soccer training. Finally, only two formats of aerobic field tests were used; other intermittent running tests (e.g., Yoyo intermittent recovery test) may have yielded different results. Such factors should be taken into consideration in future investigations.

Conclusions

To the best of our knowledge, this study is the first to examine psychometric state, physical enjoyment, and recovery associated with aerobic field testing in soccer players. Findings indicate that two commonly used incremental intensity

field tests (T-VAM and 20-m MST) produce similar primary outcomes (HRmax and MAS) while soccer players enjoy the T-VAM more than the 20-m MST. Furthermore, psychometric status and recovery quality decrease less following the T-VAM than the 20-m MST. Specifically, more negative changes in HS, TQR and PACES scores were observed following 20-m MST compared to T-VAM. The Hooper questionnaire and TQR represent useful strategies for coaching staff to monitor acute psychometric changes after testing and before the remainder of the day's practice, which could aid in test selection. Coaches can select tests such as T-VAM for evaluating aerobic fitness and ensuring athletes' psychometric well-being and physical enjoyment.

Authors' Contributions

OS and NO were responsible for the conception or the design of the manuscript, II and WA for data acquisition and processing, and OS and DEL for analysis and interpretation of the data. All authors (OS, DEL, NO, II, WA, LA, TR, AB, and BK) participated in drafting the manuscript, and DEL, LH, TR, AB, and BK revised it critically. All authors read and approved the final version of the manuscript.

Conflict of Interest

The authors declare no conflict of interest.

Acknowledgements

The authors would like to thank the athletes involved in this study.

ORCID IDs

Okba Selmi: 0000-0001-5309-8863. Danielle E. Levitt: 0000-0003-1865-1971. Antonella Muscella: 0000-0002-2822-9929. Nejmeddine Ouerghi: 0000-0002-8840-1735. Imen Issaoui: N/A. Wissal Abassi: N/A. Lee Hill: 0000-0003-2092-318X. Thomas Rosemann: 0000-0002-6436-6306. Anissa Bouassida: 0000-0003-0971-0183. Beat Knechtle: 0000-0002-2412-9103.

References

1) Cazorla G. Tests de terrain pour évaluer la capacité aérobie et la vitesse maximale aérobie. In: Cazorla G, Robert G (eds) L'évaluation activité physique et en sport. Cestas: AREAPS 1990; p. 151-174.

2) Paradisis GP, Zacharogiannis E, Mandila D, Smirtiotou A, Argeitaki P, Cooke CB. Multi-Stage 20-m Shuttle Run Fitness Test, Maximal Oxygen Uptake and Velocity at Maximal Oxygen Uptake. J Hum Kinet 2014; 41: 81-87.

3) Carminatti LJ, Possamai CAP, de Moraes M, da Silva JF, de Lucas RD, Dittrich N, Guglielmo LGA. Intermittent versus Continuous Incremental Field Tests: Are Maximal Variables Interchangeable? J Sports Sci Med 2013; 12: 165-170.

4) Selmi O, Ouergui I, Levitt DE, Nikolaidis PT, Knechtle B, Bouassida A. Small-Sided Games are More Enjoyable Than High-Intensity Interval Training of Similar Exercise Intensity in Soccer. OAJSM 2020; 11: 77-84.

5) Bartholomew JB, Morrison D, Ciccolo JT. Effects of Acute Exercise on Mood and Well-Being in Patients with Major Depressive Disorder: Med Sci Sports Exerc 2005; 37: 2032-2037.

6) Selmi O, Haddad M, Majed L, Ben Khalifa W, Hamza M, Chamari K. Soccer training: high-intensity interval training is mood disturbing while small sided games ensure mood balance. J Sports Med Phys Fitness 2018; 58: 1163-1170.

7) Selmi O, Gonçalves B, Ouergui I, Sampaio J, Bouassida A. Influence of well-being variables and recovery state in physical enjoyment of professional soccer players during small-sided games. Research in Sports Medicine 2018; 26: 199-210.

8) Thum JS, Parsons G, Whittle T, Astorino TA. High-Intensity Interval Training Elicits Higher Enjoyment than Moderate Intensity Continuous Exercise. PLoS ONE 2017; 11; 12: e0166299.

9) Heisz JJ, Tejada MGM, Paolucci EM, Muir C. Enjoyment for High-Intensity Interval Exercise Increases during the First Six Weeks of Training: Implications for Promoting Exercise Adherence in Sedentary Adults. Fisher G, editor. PLoS ONE 2016; 11: e0168534.

10) Moalla W, Fessi MS, Farhat F, Nouira S, Wong DP, Dupont G. Relationship between daily training load and psychometric status of professional soccer players. Res Sports Med. 2016; 24: 387-394.

11) Mandolesi L, Polverino A, Montuori S, Foti F, Ferraioli G, Sorrentino P, Sorrentino G. Effects of Physical Exercise on Cognitive Functioning and Wellbeing: Biological and Psychological Benefits. Front Psychol 2018; 9: 509.

12) Selmi O, Gonçalves B, Ouergui I, Levitt DE, Sampaio J, Bouassida A. Influence of Well-Being Indices and Recovery State on the Technical and Physiological Aspects of Play During Small-Sided Games: Journal of Strength and Conditioning Research 2019; 35: 2802-2809.

13) Gallo TF, Cormack SJ, Gabbett TJ, Lorenzen CH. Pre-training perceived wellness impacts training output in Australian football players. J Sports Sci 2016; 34: 1445-1451.

14) Foster C, Florhaug JA, Franklin J, Gottschall L, Hrovatin LA, Parker S, Doleshal P, Dodge C. A new approach to monitoring exercise training. J Strength Cond Res 2001; 15: 109-115.

15) Kenttä G, Hassmén P. Overtraining and Recovery: A Conceptual Model. Sports Med. 1998; 26: 1-16.

16) Hooper SL, Mackinnon LT. Monitoring Overtraining in Athletes: Recommendations. Sports Med 1995; 20: 321-327.

17) Durnin JVGA, Womersley J. Body fat assessed from total body density and its estimation from skinfold thickness: measurements on 481 men and women aged from 16 to 72 Years. Br J Nutr. 1974; 32: 77-97.

18) Haddad M, Chaouachi A, Wong DP, Castagna C, Hambli M, Hue O, Chamari K. Influence of fatigue, stress, muscle soreness and sleep on perceived exertion during submaximal effort. Physiol & Behavior 2013; 119: 185-189.

19) Kendzierski D, DeCarlo KJ. Physical Activity Enjoyment Scale: Two Validation Studies. J Sport Exerc Psychol 1991; 13: 50-64.

20) Léger LA, Mercier D, Gadoury C, Lambert J. The multistage 20 metre shuttle run test for aerobic fitness. J Sports Sci 1988; 6: 93-101.

21) Selmi O, Ouergui I, Levitt DE, Nikolaidis PT, Knechtle B, Bouassida A. Small-Sided Games are More Enjoyable Than High-Intensity Interval Training of Similar Exercise Intensity in Soccer. OAJSM 2020; 11: 77-84.

22) Hopkins WG, Marshall SW, Batterham AM, Hanin J. Progressive Statistics for Studies in Sports Medicine and Exercise Science. Med Sci Sports Exerc 2009; 41: 3-13.

23) Richard G, Edmond E, Samuel M, Brice A, Marcel A, Jerson M, Landry F, Wiliam M, Honore M, Abdou T. The 20 m2 VAMEVAL Test: A reduced space approach to determine the maximum oxygen consumption of young Cameroonians. Int J Sports Sci Phys Ed 2018; 3: 27-31.

24) García-Benítez S, Fleck SJ, Naclerio F, Martín MA, Lucia A. Resistance (Weight Lifting) Training in an Adolescent With McArdle Disease. J Child Neurol 2013; 28: 805-808.

25) Bartlett JD, Close GL, MacLaren DPM, Gregson W, Drust B, Morton JP. High-intensity interval running is perceived to be more enjoyable than moderate-intensity continuous exercise: Implications for exercise adherence. J Sports Sci 2011; 29: 547-553.

26) Oliveira BRR, Santos TM, Kilpatrick M, Pires FO, Deslandes AC. Affective and enjoyment responses in high intensity interval training and continuous training: A systematic review and meta-analysis. Stepto NK, editor. PLoS One. 2018; 13: e0197124.

27) Dellal A, Keller D, Carling C, Chaouachi A, Wong DP, Chamari K. Physiologic Effects of Directional Changes in Intermittent Exercise in Soccer Players. J Strength Cond Res 2010; 24: 3219-3226.

28) Buchheit M, Mendez-Villanueva A, Quod MJ, Poulos N, Bourdon P. Determinants of the variability of heart rate measures during a competitive period in young soccer players. Eur J Appl Physiol 2010; 109: 869-878.

29) Fullagar HHK, Skorski S, Duffield R, Hammes D, Coutts AJ, Meyer T. Sleep and Athletic Performance: The Effects of Sleep Loss on Exercise Performance, and Physiological and Cognitive Responses to Exercise. Sports Med 2015; 45: 161-186.

30) Rae DE, Chin T, Dikgomo K, Hill L, McKune AJ, Kohn TA, Roden LC. One night of partial sleep deprivation impairs recovery from a single exercise training session. Eur J Appl Physiol 2017; 117: 699-712.