South African Journal for Research in Sport, Physical Education and Recreation, 2024, 46(1): 22 - 32.
ISBN: 0379-9069

RELIABILITY AND RESPONSIVENESS OF THE *UCHI-KOMI* FITNESS TEST AMONG JUDO ATHLETES

Nafaa SOUISSI[1,2], Helmi CHAABÈNE[3], Khaled TRABELSI[2,4], Mohamed ROMDHANI[1], Hamdi CHTOUROU[1,2] and Cain C.T. CLARK[5]

[1] *Research Unit: Physical Activity, Sport, and Health, National Observatory of Sport, Tunis, Tunisia*
[2] *High Institute of Sport and Physical Education of Sfax, University of Sfax, Sfax, Tunisia*
[3] *Division of Training and Movement Sciences – Research Focus Cognition Sciences, University of Potsdam, Potsdam, Germany*
[4] *Research Laboratory: Education, Motricity, Sport and Health, University of Sfax, Sfax, Tunisia*
[5] *Centre for Intelligent Healthcare, Coventry University, Coventry, United Kingdom*

ABSTRACT

Several tests have been designed to assess the ability of judoka to repeat specific and intense efforts of short duration. To be accepted and adopted, the reliability and construct validity of the test should be confirmed. This study aimed to examine the relative and absolute reliability and the external responsiveness of an intermittent test simulating judo combat (the Uchi-Komi Fitness Test). Seventeen judo athletes of two different levels of performance (elite and non-elite), performed the Uchi-Komi Fitness Test during three sessions separated by 72 hours. The number of Uchi-Komi was recorded. In addition, blood lactate concentration and rating of perceived exertion were measured. The Uchi-Komi Fitness Test showed good relative and absolute reliability in detecting small and meaningful changes. The performances were better in elite vs. non-elite counterparts (p=0.006). Receiver operating characteristic analysis showed that the Uchi-Komi Fitness Test was able to discriminate athletes of different competitive level (receiver operating characteristic curve 0.83). The Uchi-Komi Fitness Test is a good indicator of physical fitness specific to judo and can discriminate between elite and non-elite judokas.

Keywords: Anaerobic capacity; Grappling combat sport; Physical fitness; Rating of perceived exertion; Reproducibility; Sensitivity.

INTRODUCTION

Judo is one of the most dynamic martial arts and appeared for the first time as an Olympic sport in 1964 in Tokyo. It is well-established that judo is a high-intensity intermittent martial art that requires a wide variety of complex skills and tactical nuance for success (Degoutte *et al.*, 2003). Additionally, this martial art requires starting in the vertical position, called "*Tachi-Waza*", with the possibility of continuing into a horizontal position, called "*Ne-Waza*" (Boguszewski,

2006). With respect to the temporal structure, judo matches last 4 min, with 30-s periods of activity interrupted by 10-s breaks (Miarka *et al.*, 2012). Given that decisive actions in judo rely, mostly, on powerful movements, the anaerobic contribution plays an important role during judo competition (Degoutte *et al.*, 2003). Moreover, aerobic fitness is believed to play a vital role during high-intensity intermittent exercise, as it permits (1) better recovery during the short periods of rest or reduced effort within the combat, (2) the maintenance of the level of repeated high-intensity actions, and (3) the acceleration of the recovery process between two consecutive high-intensity actions and matches (Franchini *et al.*, 2009).

From physiological and physical viewpoints, the development of anaerobic power and capacity, muscle strength/power, and aerobic power are recognised as pivotal for judokas (Thomas *et al.*, 1989). Consequently, it is imperative to conduct sport-specific assessments to evaluate both aerobic and anaerobic fitness in judo athletes. Almansba *et al.* (2007) proposed the *Uchi-Komi* Fitness Test (UFT), a sport-specific field judo test that assesses both the aerobic and anaerobic potential of judokas. It serves as an effective protocol mimicking the exertion levels experienced during a judo match. However, for widespread acceptance and adoption, it is essential to confirm the reliability and the construct validity of the UFT (Terwee *et al.*, 2003).

Preliminary evidence of the test's utility has been provided by Almansba *et al.* (2007), where the authors found that the UFT is a valid and sensitive test that can differentiate between elite and non-elite judo athletes. However, specific sensitivity analysis has yet to be conducted, and thus further work using more suitable statistical approaches (i.e., receiver operator characteristic [ROC] curve) for sensitivity analysis is needed.

Additionally, to the best of the authors' knowledge, there is only one study (Almansba *et al.*, 2011), conducted with a small number of participants (n=7), that has investigated the reliability of the UFT, albeit using a flawed statistical approach. Moreover, despite its relevance, blood lactate concentration [La] was not measured in the earlier studies. In fact, [La] is a crucial parameter that reflects the physiological stress imposed by the effort (Halson, 2014). Besides, [La] has been widely used in combat sports testing and training (Chaabene *et al.*, 2012; Chaabène *et al.*, 2014), including judo (Markov *et al.*, 2023).

PURPOSE OF RESEARCH

It is within the broad context described above that the present study was designed: (1) to evaluate the absolute and relative reliability of the UFT, and (2) to verify whether the UFT can discriminate judo athletes of different competitive levels (i.e., elite vs. non-elite level). We hypothesised that the UFT would be a reliable test for assessing the physical fitness of judokas and could discriminate between non-elite and elite levels.

METHODOLOGY

Population and sample

Seventeen black belt judokas (12 males and 5 females) who regularly participated in competitive events volunteered to participate in the present study. Nine judokas: six males and three females (age: 20.9±1.0 years, weight: 78.4±12.0 kg, height: 1.7±0.1 m, body mass index [BMI]: 22.9±2.1 $kg \cdot m^{-2}$, experience: 9.0±1.9 years) were members of the Tunisian judo elite

team and engaged in regular judo training for nine sessions per week. Eight participants: six males and two females (age: 21.4±1.1 years, weight: 64.9±8.2 kg, height: 1.7±0.1 m, BMI: 22.6±21.7 kg·m^{-2}, experience: 7.0±1.3 years) were judo practitioners of non-elite level recruited from a local judo club that trained for five sessions per week. Participants were classified as elite judo athletes based on the taxonomy of Swann (Swann score >8 [mean score=11.5±2.2]) (Swann *et al.*, 2015). All judokas provided their written informed consent, after being informed of any risks and discomforts associated with the experiment. The study was approved by the university ethics committee of the High University of Sport and Physical Education of Sfax, Protocol reference number 21/40, and was conducted in accordance with the Declaration of Helsinki.

Data collection procedure

The present study's first aim was to examine the absolute and relative reliability of the UFT. Athletes were familiarised with the test procedures before the commencement of the assessments on control days. All assessments were performed at the same time of day to reduce the effect of the diurnal variation on physical performance (Chtourou & Souissi, 2012). On separate occasions, test–retest sessions were performed separated by a period of 1 week. The second objective of the study was to examine the external responsiveness of the protocol that was performed twice, once within the non-elite judo group and the other within the elite judo group. Before the beginning of the test, athletes completed a standardised warm-up of 15 min. This comprised moderate-intensity jogging (8 min), dynamic stretching (5 min), and brief bouts of high-intensity *Uchi-Komi*. The latter consisted of practising a throwing motion repeatedly up until the point where the throw is executed, which is the exercise of *Ippon-Seoi-Nage*, with three sets of 6 seconds and 54 seconds of recovery (2 min). To ensure adequate recovery, judokas performed the UFT after 5 min rest. The judokas performed the test while wearing specific judo clothes (i.e., *judogi*). They were also asked to follow their normal diet, to consume a light meal at least 3 hours prior to each trial, to avoid all forms of vigorous activity before each test session, to sleep adequately (i.e., 7–9 hours of sleep duration) (Halson & Juliff, 2017) and to avoid any intense physical activity in the 48 hours prior to the test. This was verified by interviewing the subjects before performing the UFT test. During the test session, the same investigator provided vigorous verbal encouragement (Winkelman *et al.*, 2017). Capillary blood samples were drawn within 3 min post-test for [La] determination using the Lactate Pro Analyzer (Arkray, Tokyo, Japan). Blood lactate concentration is one of the frequently measured parameters during performance testing of athletes as it provides information about the intensity of the load. We chose to measure blood lactate after 3 min to allow sufficient time for the lactate to migrate from the cell where it was produced to the blood. Blood lactate concentration would be underestimated if measured within an interval of less than 3 min (Goodwin *et al*., 2007). The rating of perceived exertion (RPE) was measured at the end of the test.

Instrument

***Uchi-Komi* Fitness Test.** The testing protocol consisted of a suspension on a fixed bar to perform an isometric contraction of arms (during 3 s, the judoist gripped the sleeve and reverse of a judogi hanging in a high bar). After this period of isometric effort, the judoka performed a maximal shuttle run between two *Uke* 4 m apart. When *Tori* (judoka) attained *Uke*, they executed an *Uchi-Komi* (i.e., *Ippon-Seoi-Nage* and *Harai-Goshi*) (Almansba *et al.*, 2007).

The starting position consisted of the placement of *Tori* (judoka) under a fixed *judogi*. Following the start signal, *Tori* was asked to grip the *judogi* in a *kumi-kata* position (i.e., isometric contraction). The duration of the isometric phase was 3 s, and this increased by 3 s after each set. Then, over 20 s, *Tori* sprinted between two *Uke* (i.e., from the same weight category as *Tori*) separated by 4 m, and performed an *Ippon-Seoi-Nage* with *Uke* 1 and *Harai-Goshi* with *Uke* 2. Each judoka performed six sets that increased every time by 3 s during the isometric contraction. The rest between sets was 4 s and was increased by 2 s each time. The number of actions (i.e., the number of *Uchi-Komi*) was counted and recorded by one of the investigators (Almansba *et al*., 2012). The schematic description of the UFT test is shown in Figure 1.

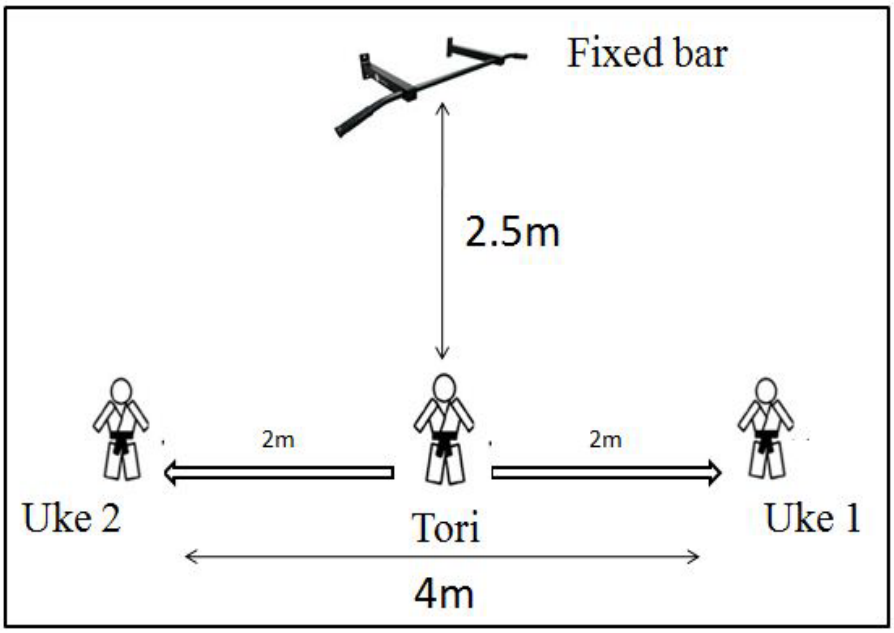

Figure 1. **SCHEMATIC REPRESENTATION OF THE TEST**

Ethical considerations

The research protocol was approved by the Committee of the High University of Sport and Physical Education of Sfax, protocol reference number 21/40.

Statistical analysis

Data were analysed using SPSS statistical software 19.0 for Windows (SPSS, Chicago, IL, USA). Data for the number of repetitions, [La], and RPE were presented as mean and standard deviation (SD). The normality assumption was checked using the Shapiro-Wilk test, where all variables showed a normal distribution. The relative reliability of UFT was established by calculating the intraclass correlation coefficient (ICC). We considered an ICC below 0.40 as poor, between 0.40 and <0.70 as fair, between 0.70 and <0.90 as good, and ≥0.90 as excellent (Coppieters *et al.*, 2002). Absolute reliability was analysed using the standard error of

measurement (SEM), expressed as coefficient of variation (CV). It was calculated by dividing the SD of the difference between scores by √2 (Hopkins, 2000). Additionally, the smallest worthwhile change (SWC) was calculated, which was determined by the rearrangement of Cohen's *d* effect size calculation, where the smallest worthwhile effect (0.2) was multiplied by the between-subject SD. Test usefulness was determined by comparing SWC to SEM using the thresholds proposed previously (Liow & Hopkins, 2003). In the case of an SEM≤SWC, the test's capacity to detect small changes was considered "good". When SEM=SWC it was considered "satisfactory", and when SEM≥SWC, the test's capacity to detect small performance changes was rated as "marginal". The following scale was used for the interpretation of *d*: <0.2 (trivial); 0.2–0.6 (small); 0.6–1.2 (moderate); 1.2–2.0 (large); and >2.0 (very large) (Scanlan *et al.*, 2012). A paired sample t-test was used to determine any learning effect and/or systematic bias between mean scores during the test–retest sessions. Heteroscedasticity was assessed using a zero-order correlation between the absolute residuals and the predicted scores for each participant. The SEM was also used to calculate MDC95%, which represents the 95% confidence interval (CI) of the difference in score between paired observations. In the present study, the MDC95% was calculated using the formula: MDC95%=SEM×√2×1.96 (Weir, 2005; Haley & Fragala-Pinkham, 2006). The external responsiveness of the UFT was analysed using the ROC curve (Deyo & Centor, 1986, Mannion *et al.*, 2005). The area under the ROC curve was interpreted as the probability of correctly discriminating between judo practitioners with a good and poor outcome. An area of 0.5 is interpreted as no discriminatory accuracy and 1.0 as complete accuracy (De Vet *et al.*, 2001). Generally, an area under the ROC curve of 0.70 is commonly considered to indicate good discriminative ability (Deyo & Centor, 1986, Mannion *et al.*, 2005). An independent samples t-test was used to compare the performance of elite and non-elite athletes in addition to the physiological and perceptual responses to the UFT. Statistical significance was accepted, *a priori*, at p≤0.05.

RESULTS

Table 1 presents the number of repetitions, [La], and RPE during the test-retest sessions. The results showed that there were no significant differences between the two test sessions in any of the measured variables.

Table 1. **NUMBER OF REPETITION (NB REP), BLOOD LACTATE CONCENTRATIONS ([LA]) AND RATING PERCEIVED EXERTION (RPE) DURING THE UFT TEST-RETEST SESSIONS**

	Test	**Retest**	***p***	**Effect size**
NB Rep	58.2±5.1	57.6±5.3	0.61	0.15 (trivial)
Peak [La] mmol/l	11.4±3.0	11.6±2.0	0.82	0.06 (trivial)
RPE (AU)	8.0±1.0	7.9±0.9	0.84	0.11 (trivial)

NB Rep=Number of repetitions; PRE= Rate of perceived exertion

The reliability statistics are shown in Table 2. Statistical analysis showed that UFT presented good relative (ICC=0.82) and absolute (SEM as CV=4.9%) reliabilities. The SEM was 2.88, which was greater than SWC (1.02), and the MDC_{95} was 8. Table 3 presents the number of *Uchi-Komi*, [La], and RPE among non-elite and elite judokas.

Table 2. **RELATIVE AND ABSOLUTE RELIABILITY OF THE *UCHI-KOMI* FITNESS TEST**

	Relative reliability	Absolute reliability			MDC_{95}
	ICC	SEM	SEM% (%)	SWC	
NB Rep	0.82	2.88	4.9	1.02	8

NB Rep=Number of repetitions ICC=Intraclass correlation coefficient SEM=Standard error of measurement SWC=Smallest worthwhile change MDC_{95}=Minimal detectable change

Table 3. **DIFFERENCES BETWEEN ELITE AND NON-ELITE-LEVEL JUDO ATHLETES IN THE NUMBER OF *UCHI-KOMI* (NB REP), BLOOD LACTATE CONCENTRATIONS ([LA]) AND PERCEIVED EXERTION (RPE) DURING THE *UCHI-KOMI* FITNESS TEST**

	Non-elite-level group (n=8)	Elite-level group (n=9)	p	Effect size
NB Rep	64±2.1	58.2±4.8	0.006	1.57 (large)
[La] mmol/l	12.1±2.3	11.3±2.5	0.53	0.31 (small)
RPE	8.1±0.7	7.5±1.1	0.17	0.69 (moderate)

Descriptive data, as well as effect sizes, from the UFT performed by elite and non-elite judokas are presented in Table 3. Independent t-tests showed that elite-level judokas had significantly better performance during the UFT than non-elite-level judokas (t=-3.16, df=15, p=0.006). There were no significant differences in [La] and RPE between the two judokas groups (p>0.05) (Table 3). The discriminant ability of the UFT was established by calculating the ROC curve between non-elite and elite-level judokas, which was 0.83 (95%CI: 0.57–0.96), showing very good discriminant ability of the UFT (Figure 2).

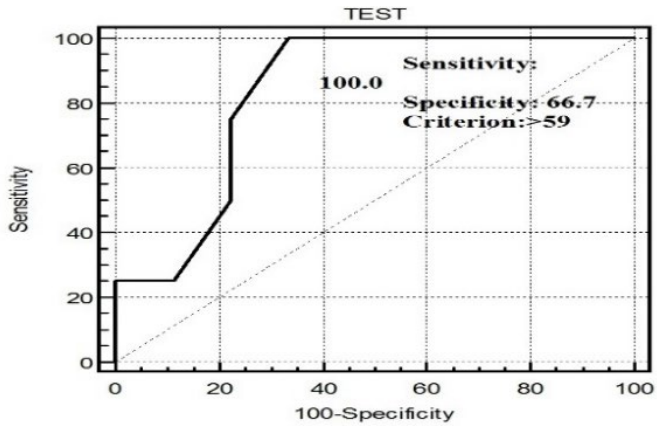

Figure 2. **RECEIVER OPERATING CHARACTERISTIC CURVE FOR THE *UCHI-KOMI* FITNESS TEST BETWEEN ELITE- AND NON-ELITE-LEVEL JUDOKAS**

DISCUSSION

The main objective of this study was to examine the reliability and discriminatory validity of the UFT. The sample size is not large but is practical for such an analysis. In this regard, other studies showing reliability had similar sample size (18 athletes; Kons *et al.*, 2018). The majority of participants were elite (9 judokas) and generally the population of elite athletes is small, meaning that it is not possible to recruit more participants. The main findings of our study suggest that the UFT is a reliable test, with a good ability to discriminate non-elite from elite-level judokas.

Specific assessment is one of the most crucial issues of contemporary training in combat sports. To use any test, certain criteria should be verified. First, a test should possess good reliability, and second, to suitably select athletes, responsiveness is considered the most essential property of an evaluative instrument (Terwee *et al.*, 2003). Additionally, a judo-specific test should reproduce the effort of the combat. Earlier studies indicated that following a judo match, athletes present a high [La], reflecting a high energy production by the glycolytic pathway (Tumilty *et al.*, 1986; Callister *et al.*, 1990). The [La] measurements during the two test sessions (11.4±3 and 11.6±2 mmol.l^{-1} for test and retest sessions, respectively) were similar to those measured in another study during a judo match (values reported ranged from 10.3±2.6 mmol.l^{-1} to 12.3±1.8 mmol.l^{-1}) (Sbriccoli *et al.*, 2007). The difference is rather small; for the elite group, blood lactate was 11.3 and in the non-elite 12.1 mmol.l^{-1}. This shows that the glycolytic system was highly taxed in both groups. We would speculate that the elite group had a better aerobic capacity, allowing them to recover faster after the end of UFT. But this would be highly speculative and less likely considering the very small difference of 0.8 mmol.l^{-1} between the two groups. Thus, the UFT could be considered as a representative test to measure the lactic anaerobic capacity of judokas. Moreover, the number of repetitions (i.e., *Uchi-Komi*) in our

study during the two sessions (58.2±5.1 and 57.6±5.3 for test and retest sessions, respectively) was slightly higher than values obtained in a previous study (Almansba *et al.*, 2012) (51.3±2.56, 51.3±1.98 and 52.0±2.58, during sessions 1, 2 and 3, respectively). Indeed, this difference could be attributed to the competitive level of participants. In study of Almansba (2012), only one elite-level judoka was among the participants, while in our study, eight judokas of an elite level were among the participants.

To examine the reliability of the UFT, ICC and SEM were calculated. While ICC measures the relative reliability, SEM is an index of absolute reliability (Looney, 2000). Accordingly, in our study, ICC value for the number of *Uchi-Komi* repetitions was 0.82, indicating a high reliability of the test (Coppieters *et al.*, 2002). In a previous study (Almansba *et al.*, 2012), the ICC for the number of *Uchi-Komi* repetitions was 0.97, which indicated a high reliability of the test. A high value of ICC may be explained by a high heterogeneity between judoka levels (Weir, 2005). Moreover, as the SEM was not affected by between-subject variability, as was the case for ICC (Weir, 2005), its calculation would be useful to determine reliability of a test. In our study, the SEM was 4.9%, which was slightly below the reference value of 5% previously suggested as a limit of the difference between any two performances in the same test performed on different days (Nevill & Atkinson, 1997). Nevertheless, Almansba *et al.* (2012) reported a very low typical error measurement (<2%) for the total number of *Uchi-Komi*.

Importantly, given that the aim of a test is to select athletes, it should be able to differentiate athletes of different competitive levels. In the current investigation, findings indicated a large, significant difference (ES=1.57) in the total number of *Uchi-Komi* repetitions performed between elite and non-elite judokas ($p<0.01$). This suggests a superior performance among elite judokas compared with their non-elite counterparts. However, there were no significant differences between elite and non-elite judokas in RPE scores and (La) in the retest session. Concordant results were reported for RPE responses during a specific karate test (Chaabène, 2012), and these results can be explained by a better skills mastery and better movement economy at the elite-level group versus non-elite-level judokas (Chaabène, 2012).

Alternative methods such as ROC curve analysis are gaining popularity and can be used to validate the discriminant ability (Deyo & Centor, 1986). Thereby, a performance test may be considered responsive if its area under the ROC curve is ≥0.70 (Deyo & Centor, 1986). Indeed, the area under the ROC curve represents the probability of correctly discriminating elite from non-elite judokas using UFT. In the present study, we found that the area under the ROC curve was >0.70 (0.83; CI 95%: 0.57–0.96), which further confirms the responsiveness of the test.

Although we employed rigorous statistical analyses to discern the reliability and responsiveness of the UFT, our study had some limitations that should be acknowledged. First, physiological and perceptual responses to the UFT were not compared with those of a judo combat. Nevertheless, [La] measured during the two test sessions was similar to that measured in other studies during a judo match (Sbriccoli *et al.*, 2007; Franchini *et al.*, 2009) Second, heart rate monitoring was not performed during UFT. Accordingly, further studies are needed to confirm the veracity of our findings.

Practical application and conclusion

Coaches and athletes could use this specific test to assess the physical capacity of judokas. The UFT appears to be a reliable and valid test for measuring physiological and perceptual responses during a specific judo task. Moreover, it can be used as a tool to accurately discriminate judo athletes of different levels of practice. It is therefore a reliable test that allows us to identify and select the different levels of judokas.

Acknowledgements

We thank all participants for participating in this study.

Conflict of interest

The authors declared not conflict of interest.

REFERENCES

ALMANSBA, R.; STERKOWICZ, S.; BOUZELATA, R. & COMTOIS, A.S. (2011). Metabolic and cardiovascular responses of the Canadian world-class judoist at the Uchikomi Fitness Test (UFT). Proceedings of "The 7th International Judo Research Symposium Sports", 22 August 2011. Paris, France.

ALMANSBA, R.; STERKOWICZ, S.; STERKOWICZ-PRZYBYCIEŃ, K. & COMTOIS, A.S. (2012). Reliability of the uchikomi fitness test: A pilot study. Reliability of the uchikomi fitness test. *Science & Sports,* 27: 115-118.

ALMANSBA, R.; FRANCHINI, E. & STERKOWICZC, S. (2007). An Uchi-komi with load, a physiological approach of a new special judo test proposal. *Science & Sports,* 22: 216-223.

BOGUSZEWSKI, D. (2006). Fight dynamics of the double Olympic champion in judo (1988-1992). *Journal of Human Kinetics,* 16: 97-106.

CALLISTER, R.; CALLISTER, R.J.; FLECK, S.J. & DUDLEY, G.A. (1990). Physiological and performance responses to overtraining in elite judo athletes. *Medicine & Science in Sports & Exercise,* 22: 816-824.

CHAABÈNE, H.; FRANCHINI, E.; MIARKA, B.; SELMI, M.A.; MKAOUER, B. & CHAMARI, K. (2014). Time–motion analysis and physiological responses to karate official combat sessions: Is there a difference between winners and defeated karatekas ? *International Journal of Sports Physiology and Performance,* 9(2): 302–308.

CHAABENE, H.; FRANCHINI, E. & MKAOUER, B. (2012). *Reliability and construct validity of the karate specific aerobic test (KSAT). February*. *Journal of Strength and Conditioning Research*, 26(12): 3454–3460. https://doi.org/10.1519/JSC.0b013e31824eddda

CHAABÈNE, H.; HACHANA, Y.; ATTIA, A.; MKAOUER, B.; CHAABOUNI, S. & CHAMARI, K. (2012). Relative and Absolute Reliability of Karate Specific Aerobic Test (Ksat) in Experienced Male Athletes. *Biology of Sport,* 29.

CHTOUROU, H. & SOUISSI, N. (2012). The effect of training at a specific time of day: A review. *Journal of Strength and Conditioning Research,* 26(6): 1984-2005.

COPPIETERS, M.; STAPPAERTS, K.; JANSSENS, K. & JULL, G. (2002). Reliability of detecting 'onset of pain' and 'submaximal pain' during neural provocation testing of the upper quadrant. *Physiotherapy Research International,* 7(3): 146-156.

DE VET, H.C.; BOUTER, L.M., BEZEMER, P.D. & BEURSKENS, A.J. (2001). Reproducibility and responsiveness of evaluative outcome measures. Theoretical considerations illustrated by an empirical example. *International Journal of Technology Assessment in Health Care,* 17(4): 479-487.

DEGOUTTE, F.; JOUANEL, P. & FILAIRE, E. (2003). Energy demands during a judo match and recovery. *British Journal of Sports Medicine,* 37(3): 245-249.

DEYO, R.A. & CENTOR, R.M. (1986). Assessing the responsiveness of functional scales to clinical change: an analogy to diagnostic test performance. *Journal of Chronic Disease,* 39(11): 897-906.

FRANCHINI, E.; DE MORAES BERTUZZI, R.C.; TAKITO, M.Y. & KISS M.A. (2009). Effects of recovery type after a judo match on blood lactate and performance in specific and non-specific judo tasks. *European Journal of Applied Physiology,* 107(4): 377-383.

GOODWIN, M.L.; HARRIS, J.E.; HERNÁNDEZ, A.; GLADDEN, L.B. (2007). Blood lactate measurements and analysis during exercise. *Journal of Diabetes Science and Technology*, 1(4): 558-569.

HALEY, S.M. & FRAGALA-PINKHAM, M.A. (2006). Interpreting change scores of tests and measures used in physical therapy. *Physical Therapy,* 86(5): 735-743.

HALSON, S.L. & JULIFF, L.E. (2017). Sleep, sport, and the brain. *Progress in Brain Research,* 234: 13-31.

HALSON, S.L. (2014). Monitoring training load to understand fatigue in athletes. *Sports Medicine,* 44(Suppl 2): S139-S147. https://doi.org/10.1007/s40279-014-0253-z

HOPKINS, W.G. (2000). Measures of reliability in sports medicine and science. *Sports Medicine,* 30(1): 1-15.

LIOW, D.K. & HOPKINS, W.G. (2003). Velocity specificity of weight training for kayak sprint performance. *Medicine & Science in Sports & Exercise,* 35(7): 1232-1237.

LOONEY, M.A. (2000). When is the intraclass correlation coefficient misleading? *Measurement in Physical Education and Exercise Science,* 4(2):73-78.

MANNION, A.F.; ELFERING, A.; STAERKLE, R.; JUNGE, A.; GROB, D.; SEMMER, N.K.; JACOBSHAGEN, N.; DVORAK, J. & BOOS, N. (2005). Outcome assessment in low back pain: How low can you go? *European Spine Journal,* 14(10): 1014-1026.

MIARKA, B.; PANISSA, V.L.; JULIO, U.F.; DEL VECCHIO, F.B., CALMET, M. & FRANCHINI, E. (2012). A comparison of time-motion performance between age groups in judo matches. *Journal of Sports Science,* 30(9): 899-905.

NEVILL, A.M. & ATKINSON, G. (1997). Assessing agreement between measurements recorded on a ratio scale in sports medicine and sports science. *British Journal of Sports Medicine,* 31(4): 314-318.

SBRICCOLI, P.; BAZZUCCHI, I.; DI MARIO, A.; MARZATTINOCCI, G. & FELICI, F. (2007). Assessment of maximal cardiorespiratory performance and muscle power in the Italian Olympic judoka. *Journal of Strength and Conditioning Research,* 21(3): 738-44.

MARKOV, A.; BUSSWEILER, J.; HELM, N.; ARNTZ, F.; STEIDTEN, T. & KROHM, L. (2023). Acute effects of concurrent muscle power and sport - specific endurance exercises on markers of immunological stress response and measures of muscular fitness in highly trained youth male athletes. *European Journal of Applied Physiology*, 123(5): 1015-1026. https://doi.org/10.1007/s00421-022-05126-8

SCANLAN, A.T.; DASCOMBE, B.J. & REABURN, P.R. (2012). The construct and longitudinal validity of the basketball exercise simulation test. *Journal of Strength and Conditioning Research,* 26(2): 523-530.

SWANN, C.F.; MORAN, A. & PIGGOTT, D. (2015). Defining elite athletes: Issues in the study of expert performance in sport psychology. *Psychology of Sport and Exercise,* 16(1):3-14.

TERWEE, C.B.; DEKKER, F.W.; WIERSINGA, W.M. PRUMMEL, M.F. & BOSSUYT, P.M. (2003). On assessing responsiveness of health-related quality of life instruments: guidelines for instrument evaluation. *Quality of Life Research,* 12(4): 349-362.

THOMAS, S.G.; COX, M.H.; LEGAL, Y.M.; VERDE, T.J. & SMITH, H.K. (1989). Physiological profiles of the Canadian National Judo Team. *Canadian Journal of Sport Science,* 14(3): 142-147.

TUMILTY, D.; HAHN, A. & TELFORD, R. (1986). Physiological profile of well trained male judo players. Commonwealth and International Conference on Sport Physical Education. *Dance, Recreation and Health*, 3-10.

WEIR, J.P. (2005). Quantifying test-retest reliability using the intraclass correlation coefficient and the SEM. *Journal of Strength and Conditioning Research,* 19(1): 231-240.

WINKELMAN, N.C.; CLARK, K.P. & RYAN, L.J. (2017). Experience level influences the effect of attentional focus on sprint performance. *Human Movement Science,* 52: 84-95.

Corresponding author: Dr Nafaa Souissi; **Email:** *nafaa.souissi@isseps.usf.tn*