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Original article

Reliability and accuracy of Cooper's test in male long distance runners

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ABSTRACT

Objective: Endurance capacity can be assessed by field test such as Cooper's test; however, reliability and accuracy are rarely reported in the literature. It was our aims to describe reliability and accuracy of Cooper's test in long distance runners.
Method: Fifteen male long distance runners performed twice all-out Cooper's test in a 400 m track. Total distance covered, maximum heart rate (HR) and rate of perceived exertion were recorded. Bias correction factor (Bc) was used to describe accuracy and the main dimensions of reliability were calculated by an intraclass correlation coefficient (ICC), effect size (ES) and agreement analysis.
Results: Accuracy for total distance and HR were relatively high (Cb = 0.994 and 0.956). Reliability for covered distance was as small as 1.7% (52.2 m) and ICC was 0.99; additionally, neither proportional nor systematical bias was detected in the agreement analysis.
Conclusions: All together, our results may confirm a good accuracy and reliability of Cooper's test in amateur long distance runners. Also, improvements or impairment lower than 52.2 m must not be associated with exercise training or retraining, since they are below the values of intra-subject reliability.
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Fiabilidad y precisión del test de Cooper en corredores varones de larga distancia

Palabras clave:
Atletas Amateur
Test de campo
Factor de corrección de sesgo
Error técnico de medición
Análisis de concordancia
Coeficiente de correlación intraclase
Tamaño del efecto

RESUMEN

Objetivo: La capacidad de resistencia puede ser evaluada por una prueba de campo como el test de Cooper, sin embargo, la precisión y fiabilidad son raramente divulgados en la literatura. Es nuestro objetivo describir la fiabilidad y la exactitud del test de Cooper en corredores de larga distancia.
Método: Quince varones fondistas realizaron pruebas de Cooper dos veces en una pista de 400 metros. La distancia recorrida, la frecuencia cardíaca máxima (FC) y la percepción de esfuerzo fueron registradas. El factor de corrección de sesgo fue utilizado para describir la exactitud y las dimensiones de la fiabilidad y se calcularon los coeficientes de correlación intraclase (CCI), el tamaño del efecto y un análisis de concordancia.
Resultados: La precisión de distancia total recorrida y de la frecuencia cardiaca fueron relativamente altas (Cb = 0.994 y 0.956). La confiabilidad para el recorrido era tan pequeña como el 1.7% (52.2 metros) y el CCI de 0.99, además no se detectó ni sesgo proporcional ni sistemático mediante el análisis de concordancia.
Conclusiones: Nuestros resultados pueden confirmar una buena exactitud y fiabilidad del test de Cooper en corredores de larga distancia aficionados. También, las variaciones inferiores a 52.2 metros no deben ser asociados con el ejercicio de entrenamiento o desentrenamiento, puesto que están por debajo de la fiabilidad intra-sujeto.
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Fiabilidade e precisão do teste de Cooper em corredores de longas distâncias do sexo masculino

Palavras-chave:
Atletas amadores
Teste de campo resistência
Fator de correção de viés
Erro técnico de medição
Análise de concordância
Coeficiente de correlação intraclasse
Tamanho do efeito

R E S U M O

Objetivo: A capacidade de resistência pode ser avaliada pelo teste de campo, tal como o teste de Cooper; no entanto, a fiabilidade e precisão são raramente relatados na literatura. O objetivo foi descrever a fiabilidade e precisão do teste de Cooper em corredores de longa distância.
Método: Quinze corredores de longa distância do sexo masculino realizaram teste de Cooper 2 vezes, numa faixa de 400 metros. Distância total percorrida, frequência cardíaca máxima (FC) e taxa de esforço percebido foram registadas. Fator de correção do viés (BC) foi usado para descrever a precisão e as principais dimensões de fiabilidade foram calculados por meio do coeficiente de correlação de intraclasse (ICC), tamanho do efeito (ES) e análise de concordância.
Resultados: A precisão da distância total e frequência cardíaca eram relativamente altas (Cb = 0.994 e 0.956). Fiabilidade para o curso era tão pequena quanto 1.7% (52.2 metros) e ICC de 0.99, além disso, uma vez que nem viés proporcional, nem sistemático foram detetados através da análise de jogo.
Conclusões: Os nossos resultados podem confirmar uma boa precisão e fiabilidade do teste de Cooper em corredores de longa distância amadores. Além disso, melhorias ou prejuízo menor do que 52.2 metros não devem ser associados a treinamento físico ou destreinamento, uma vez que estão abaixo dos valores de fiabilidade intrassujeitos.

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Introduction

Maximum oxygen uptake (VO_{2max}), lactate thresholds and running economy have been widely used to assess endurance and aerobic capacity in middle and long distance runners, and all related to athletic performance.[1] However, these variables are time consuming and expensive in field settings still; indirect tests can be utilized to substitute these latter assessments. The utility of a test depends on its validity, accuracy and reliability (reproducibility). Validity can be assumed if a test represents accurately those features of the phenomena, which are aimed to describe, explain or theorise.[2]

Regarding accuracy, this is the degree of a test to measure the true value. Finally, reliability informs about reproducibility of a test and a procedure of repeated measures is used in order to calculate repeatability; so we can consider reliability as the degree to which an assessment tool produces stable and consistent results (also known as test–retest reliability). Both low reliability and accuracy may limit applicability and utility of field performance tests.

However, utility of field tests has commonly relied on construct validity, usually associated with the capacity of the test to estimate or be associated with laboratorial variables or clinical tests.[3] In this sense, one of the most studied physiological constructs is VO_{2max}, which determines the maximum aerobic capacity and should be related with endurance and long-term performance.[4] Thus, several field tests have been created in order to obtain a valid and reliable estimation of VO_{2max}. One of the first tests developed to estimate VO_{2max} was Cooper's test, which is a simple time limit single-stage test, where athletes need to cover as many meters as possible during a 12-min all-out test.[5] The VO_{2max} estimated from Cooper and a multistage shuttle run tests has been strongly correlated in young healthy adults, which may confer a good concurrence at least for this population. The same study showed a good reliability (Φ: 0.96) and acceptable systematic error of 4.3% for maximal oxygen uptake prediction.[6] However, the Cooper's test accuracy has not been still reported to date. Also, there are a lack of data of reliability and accuracy data in athletes.

Since, there is a lack of knowledge about the reproducibility (test–retest reliability) characteristics of field tests to estimate endurance capacity such us Cooper's test in long distance runners, it was our aim to analyze the reliability and accuracy of Cooper's test on amateur long distance runners over two repeated measures (test–retest).

Method

Subjects

Fifteen adult male amateur athletes (34.5 ± 1.9 years, and 3.7 ± 4.6 years of training) volunteered to participate in the study. All athletes were informed of the study characteristics, procedures and risks; afterwards a signed informed consent was obtained from those who decided to be enrolled. The Ethical Review Institutional Board (IRB) at the University of Malaga approved the research protocol.

Experimental procedures

Test–retest approach was used by repeating Cooper's test twice in a period of 48 h. Reliability analysis was carried out in all variables obtained from the Cooper test such as distance, heart rate (HR) at the end of the test and the rate of perceived exertion (RPE). Two Cooper's tests split by 48 h were carried out in a synthetic track of 400 m, and under similar meteorological conditions. Every day athletes followed thoroughly the same protocol: firstly, a 15-min running warm-up was performed at between 50 and 70% of the theoretical maximal HR (220-Age). Then, the original Cooper's test was executed; briefly, athletes were asked to run all-out during 12-min along the inner lane of the track; immediately afterwards a member of research team recorded the distance in meters by placing a mark exactly in the point where every athlete stood still. Also, the HR at the end of test was recorded by using a HR monitor Polar RS300X (Polar Electro, Finland), and the RPE using the 0–10 Borg scale was individually asked to each participant.[7]

Statistical analysis

The accuracy of total distance in Cooper's test, maximal HR and RPE were calculated by bias correction factor (Cb) from concordance correlation coefficient analysis. Absolute reliability was reported as the mean differences, coefficient of variation (CV),

Table 1
Anthropometric and training variables of the sample.

Variable	Mean ± SD
Weight (kg)	67.3 ± 10.7
Height (cm)	171.0 ± 6.8
Age (years)	34.5 ± 1.9
Body mass index (kg/m^2)	22.9 ± 1.5
Training time (years)	3.7 ± 4.6
Km/week (km)	44.8 ± 9.8

($\sqrt{((\Sigma(\text{test}_1 - \text{test}_2)^2)/2N)}$), the standard error of the mean (SEM) and the effect size (ES) using the *d* coefficient of Cohen. For this study, an ICC < 0.50 was considered fair; from 0.50 to 0.75 was considered good and >0.75 excellent. Also, Cohen's *d* ES of 0.20 was considered small, 0.50 medium, and 0.80 large. The relative reliability was studied using the intraclass correlation coefficient (ICC) and relative CV (%CV, (CV/mean 100)). An agreement analysis was conducted to confirm systematic and proportional bias by using Bland and Altman plots[8] and Kendall's Tau rank correlation coefficients.

Results

Statistical analysis of the anthropometric and training characteristics of the sample are reported in Table 1. In this sample, inter-subject variability for total distance covered was 10.9–11.8% for the distances of 1st and 2nd test respectively, which reflected the dispersion of the results around the mean of the population. The accuracy of Cooper's test was relatively high for distance (Cb = 0.994) and HR (Cb = 0.956) but low for RPE (Cb = 0.478).

No significant differences were found between test 1 and 2 either for total distance or HR. Additionally, our ICC results from test–retest data indicated that Cooper's test had a very good reliability for covered distance and HR (Table 2). Regarding RPE, we observed a good ICC, although a significant difference was found between RPE in the first and second test ($P < 0.001$, Table 2).

Agreement analysis from the Bland–Altman plots did not showed systematic error for both, distance (difference = −20.5 m, $P > 0.05$) or maximal HR (difference = −1.1 bpm, $P > 0.05$), neither proportional bias as confirmed by Kendall's Tau rank correlation coefficient between differences and mean of measurements (Fig. 1).

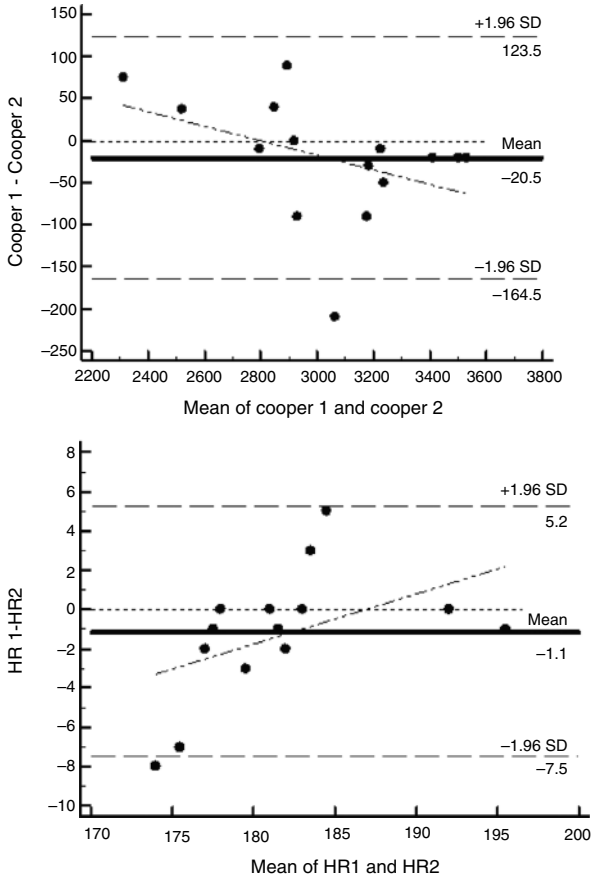

Fig. 1. Scatter plots are agreement analysis by Bland–Altman plots between the difference and the mean of the Cooper's test variables. Upper figure represents total distance and lower figure is maximal heart rate at the end of the test. Horizontal solid lines represent zero difference: horizontal dots lines indicate mean of differences; horizontal dashed lines are limits of agreement (±1.96 standard deviations). Trend line indicates proportional error explored by Tau's Kendall rank correlation coefficient (all $P > 0.05$). HR: heart rate.

Discussion

The aim of this study was to perform a preliminary reliability and accuracy of the Cooper's test in amateur long-distance runners. Our data support a good reliability as suggested previously by other authors, who studied the reliability of Cooper's test in non-athletic samples.[5,6] In spite of small differences between the two trials, CV of Cooper's test remained still around 52.2 m, although in relative units it was as low as 1.7%. This moderately high CV could be explained by the great heterogeneity of the athletic performance of the sample (range: 2350–3520 m trial 1 and 2275–3540 m trial 2), so the same absolute distance may represent similar percentages for high and low extremes in performance. In spite of the limitation, this may offer better generalization of our results since they included a larger range of performances and may highlight the bias of reliability data from a previous study where a more homogenous sample than ours was analyzed.[5] Moreover, the ES of the differences was as low as 0.059 and the non-significant difference on covered distances between trials may indicate the good repeatability of this test.

Table 2
Relative and absolute reliability of Cooper's test variables.

Reliability	Distance 1 (m)	Distance 2 (m)	HR1 (bpm)	HR2 (bpm)	RPE1	RPE2
Mean ± SD	3026 ± 330	3047 ± 359	182 ± 7.3	183 ± 5.7	8.7 ± 0.6	9.5 ± 0.5
Mean diff (95% CI)	20.46 (−20.22 to 61.15)		1.13 (−066 to 2.93)		0.8 (0.48–1.11)*	
ICC (95% CI)	0.99 (0.96–0.99)		0.93 (0.80–0.98)		0.68 (0.05–0.89)	
CV (CV %)	52.2 (1.7%)		2.4 (1.3%)		0.7 (7.5%)	
SEM	18.97		0.8387		0.1447	
Cohen's *d*	0.059		0.173		1.405	

Data in the table are from two repeated all-out Cooper's test. 1 and 2 subscripts indicate first and second Cooper's test respectively. HR, maximal heart rate during the last minute of the test; SD, standard deviation; Mean diff, mean difference between first and second test; IC, interval of confidence; ICC, intraclass correlation coefficient; CV, coefficient of variation (CV (original units) = $\sqrt{\Sigma(\text{test}_1 - \text{test}_2)^2/n}$; % cv = cv/mean × 100); SEM, standard error of the mean; RPE, rate of perceived exertion (scale from 0 to 10).

* $P < 0.001$, for paired sample *T*-test.

Firstly, these results may be helpful for coaches and scientists when prescribing training load, reporting VO_{2max} changes or predicting performance in order to interpret the variability of their outcomes. On the other hand, researchers could use these data in order to calculate sample size. This study does not lack of limitations, and our results could be biased by the intensity of test, so it can be argued that the athletes did not exercise at maximum or same effort in both trials. By using HR, the intensity of aerobic exercise test may be easily confirmed. In this study, all participants reached theoretical maximal HR values as predicted from age, which may suggest that both trials were performed all-1 out. In relation with heart rate reliability, it was also observed a CV was also observed among 4 and 3.1%, a low effect size of the difference (0.17), as well as very low absolute reliability for the maximal HR (1.13 bpm); all together these results suggest that trials 1 and 2 were similar in intensity. Additionally, RPE is a recognized marker of intensity and homeostatic disturbance during exercise and it is usually monitored during exercise tests to complement other dimensions of intensity.[9] Garcin analyzed the reliability of the HR and RPE in progressive and constant intensity exercises, concluding that these variables are reliable and replicable in these exercises.[10] Nevertheless, our results did not confirm this latter evidence and RPE had a low reliability as confirmed by the very large ES found (1.4). A plausible reason for this disagreement may be related with the poor experience of athletes in using this variable.

In conclusion our results showed that the Cooper's test is highly reliable when repeated after 48 h as confirmed by HR and distance data. This study provided support for the Cooper's test as an accurate and reliable test to assess performance in a sample of amateur long-distance runners. Nonetheless, more studies are it must be necessary in order to validate performance-related constructs with Cooper's test to confirm its utility as training tool in field settings.

Conflict of interest

The authors declare to have no conflict of interest.

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