

Representation, reliability and reproducibility of the running test using a metronome

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Abstract. Results of familiarization, assessment of reliability and comparability of results of the test run in a metronome rhythm are presented. The purpose of the research: to describe use and to estimate reliability of the test run in a metronome rhythm which was carried out by students-sportsmen of different sports specializations. **Objects:** the prepared students (boys n = 26 and girls n = 14). **Methods:** anthropometry; testing (run for 4 minutes in a metronome rhythm which changed: the first minute – 140 bpm, the second minute – 150 bpm, the third minute – 160 bpm, the fourth minute – 170 bpm; video filming and video analysis. **Results:** the reliable interrelations are revealed as a result of Pearson correlation calculation for indicators of testing No. 1-2-3: average HR (r=0.77-0.65); average distance length (r=0.85-0.54). Interclass coefficient of correlation for: average HR (r=0.64-0.65); distances of run (r=0.84-0.51); average speed of run (r=0.84-0.51). **Conclusions:** the sufficient reliability and stability of the test were shown because the extent of coincidence of results at the repeated testing had the reliable correlations and coherence during rather long period (three weeks). The test has the sufficient coherence as the scenario of its carrying out allows providing independence of results of testing of personal qualities of the individual who is carrying out the test. It can be recommended to runners for endurance for assessment of technique features; to other groups of individuals for the assessment of state of motor function, profitability and efficiency of movement, psycho-emotional features.

Keywords: metronome, testing, retest, locomotion, aerobic

Introduction.

Laboratory and field tests for the assessment of physical indicators using a metronome are widespread in practice of doctors, coaches, researchers [12; 13]. Likewise run is one of the most often used exercises for aerobic trainings for the purpose of increase and control of VO₂max of runners and not runners [18].

The type of exercises is continuous, but also intermittent tests are met in the majority of tests [11]. The most popular are such which assume shuttle run with different on characteristics intervals [16]. The set or motivational gravity of physical activity is also different. In principle, any stress testing assumes full or about full strenuous exercises or continuous loadings to exhaustion [11]. Accuracy of dosing, accounting and fixing of load and also assessment of indicators in the process and after testing becomes the important meaning.

They most often resort to laboratory researches of endurance. However, there are a number of field tests which without excessive complexity and also with the satisfactory level of informational content give the chance to estimate different aspects of a physical state of the individual [4]. Such tests use the simplest ways and tools. Assessment is made quickly and doesn't assume full loads. Similar tests can be used by different population groups [15]. However, the motivation of participants of testing remains the problem. Dosing of load by means of auditory stimulation is one of the ways of its solution. Thus, an examinee will run, following the imposed rhythm [1].

Such testing will allow solving the circle of problems:

- to estimate ability to follow a rhythm and to coordinate locomotion (psychophysiological features and the individual's state);
- to define physiological reaction on stepwise the raising load;
- to reveal features of movement of the individual at solving the task to follow the imposed rhythm.

Information on reproducibility, informational content and validity of the test is also important.

The presented option of auditory stimulation leans on hypotheses of respiratory-locomotor coupling [8; 9], sensomotor synchronization [10] and «binding» of locomotion to an external auditory stimulus [6].

Purpose. To describe use and to estimate reliability of test run in a metronome rhythm which was carried out by students-sportsmen of different sports specializations

Hypothesis. We assumed that run with auditory stimulation as a metronome, can act as test physical exercise.

Objects and methods.*Statement for ethics.* The research was approved by The Ethical Review Committee of Kharkov state academy of physical culture and all subsequent procedures corresponded to The Declaration of Helsinki.

Objects: the prepared students (boys n = 26 and girls n = 14) are almost healthy. They gave their written evidence on participation in the research and had an opportunity to obtain any information related throughout the entire period of carrying out. Characteristics of students-sportsmen, who took part in the testing, are presented in the table 1.

Table 1

№	Subject characteristics	Mean	Std.Dev.	Coef.Var.
1	Body mass (kg)	62,85	10,16	16,17
	Height (sm)	173,08	8,78	5,07
	Heart rate (bpm)	73,10	6,30	8,62
2	Body mass (kg)	64,16	11,37	17,72
	Height (sm)	174,00	8,90	5,11
	Heart rate (bpm)	71,60	6,13	8,56
3	Body mass (kg)	65,10	10,85	16,67
	Height (sm)	174,03	8,93	5,13
	Heart rate (bpm)	70,38	5,47	7,77

Methods. Anthropometry; testing; video filming and video analysis.

Anthropometry. Body weight (kg) of examinees was fixed before the testing, without footwear in a t-shirt and shorts, by means of bathroom scales Xiaomi Mi Smart Scale (China). Height (cm) was fixed in a standing position by means of the auxanometer Person-Check KaWe (Germany).

Testing. Preliminary procedures. Participants (n=60) within one week (4 trainings) were instructed and tested run in the set metronome rhythm (140, 150, 160, 170 bpm) before the research. Students, who mastered run with a target frequency of ± 5 beats, created the test group (n=40: 26 boys and 14 girls).

The main testing. Students-sportsmen (groups on 5 persons) on the command «Go!» carried out run within 1 min. (only 4 min.) in a metronome rhythm which raised every minute (140, 150, 160, 170 beats/min). Run was carried out on the platform with a soil covering, on section of 20 m with a bright marking through each meter which was limited to cones. The signal of a digital electronic metronome was given via a portable audio system. Upon the termination of 1, 2, 3 minutes fixed heart rate (HR; bpm) and the overcome distance (m) then examinees returned to one of cones to start the next minute of run (in total 15 ± 5 s is spent on fixing of indicators). The signal to the beginning of run execution in the set rhythm was given in the process of preparedness of all examinees. Upon the termination of 4 minutes; in case of refusal to continue run; substantial increase of HR (> 185 bpm); explicit mismatch of the set run rhythm, fixed HR and the overcome distance. The admissible for continuation of run considered HR = 180 ± 5 bpm. All test sessions were written on the video camera which was located frontally on a support at the height of 1 m above the ground, at distance of 10 m from the line of the movement of examinees. Video filming was carried out by the standard technique [7].

Such testing was carried out 3 within three weeks. Testing was held in the same day (Tuesday), at the same time (12:00 RM). Examinees were asked to refrain three days before testing from intake of any stimulating substances and bad habits. Conditions of conducting the testing were invariable concerning the venue, the covering, the environment ($t^{\circ}C=15-18$; Pa=730-780 mm Hg; without any precipitations; wind – 0-1.9 m/s).

Participants (n=40) were instructed about rules and the purpose of testing before the research.

Measurements. Run rhythm reported with the help of the tuner-metronome Boss TU-88 Black (Japan) connected to portable acoustics Air Music CUP (China). The delay caused by wireless audio delivery was insignificant (columns were on a support, at the level of the camera). By means of the cardiosensor Polar H10 and sports watch Polar M400 (Finland) fixed HR at the end of every minute of run. Information from the cardiosensor was instantly transmitted via Bluetooth on the laptop Acer Aspire E1-510 (China).

Video analysis. The average speed of run for every minute was determined by the software Dartfish (Switzerland) in the analysis of the slowed-down video filming.

Statistics. The statistical analysis was carried out by means of a packet of the computer programs Statistica 10 (USA) and MS Excel 2016 (USA). The analysis of compliance of the selective data to the normal distribution law was made by means of the Kolmogorov-Smirnov test (with the correction of Lilliefors). All results showed normality of distribution. Parametrical and nonparametric methods of the analysis: descriptive statistics; Pearson correlation coefficient; Student's t-test for independent selections; interclass correlation test (ICC; the bilateral fixed model, coherence option) used for the description, estimates of interrelation and difference between indicators which investigated. The Blend – Altman method was applied to the assessment of shift and limits of consent between results of three testing. We calculated their difference for each couple of measurements executed by one and another method. We calculated also average difference and a standard deviation of a difference. The average difference characterizes systematic discrepancy, and the standard

deviation – dispersion degree of results [2]. The significance value was accepted by 95% ($p < 0.05$) and all results are presented as mean value \pm a standard error.

Results.

All examinees ($n=40$) finished three tests. Run frequency (setting of a leg on a support) corresponded to a rhythm which was set by a metronome, with insignificant deviations $SD \pm 9$ (test 1); 8 (test 2); 6 (test 3) bpm. The results of the research are presented in the table 2. The variation coefficient for indicators of average HR changed slightly [6.14; 6.19; 6.17], and for indicators of distance length and average speed of run decreased [7.97; 5.22; 5.05]. The general coefficient of a variation for indicators of average HR and distance length of run for three testing made 15.07 and 15.16. The variation coefficient for indicators of average speed of run and for distance length indicators for three testing made 14.54.

Table 2

		Mean	Std.Dev.	Mean	Std.Dev.	Mean	Std.Dev.
		*		**		***	
1	Average HR (1-4 min.)	157,49	27,56	155,84	13,93	157,29	13,02
2	Average total distance(1-4 min.)	592,30	67,97	598,53	73,90	621,73	77,04
3	Average speed of run (1-4 min.)	2,47	0,20	2,49	0,13	2,59	0,13
Reliability of differences		t			p		
1	*_ **	1,29			<0,05		
	_ *	0,82			<0,05		
2	*_ **	0,99			<0,05		
	_ *	2,02			<0,05		
3	*_ **	0,97			<0,05		
	_ *	2,01			<0,05		

Notes: * – testing No. 1; ** – testing No. 2; *** – testing No. 3.

The reliable differences between the measured indicators weren't revealed ($p < 0.05$) at the consecutive comparison of results of the testing. The reliable interrelations are revealed as a result of Pearson correlation calculation for indicators which were recorded when conducting three testing. The correlations of strong and average force are revealed for the first and the second ($r=0.77$) and the second and the third testing ($r=0.65$), are recorded for average values of HR correlations. The correlations of strong and average force are revealed for the first and the second ($r=0.85$) and the second and the third testing ($r=0.54$), are recorded for indicators of average distance length of run. The interclass correlation coefficient for average values of HR ($r=0.641$) between results of the first and the second test protocols was ranging from weak to high interrelation [0.417; 0.792], and the correlation ($r=0.653$) was in limits [0.434; 0.800] between results of the second and the third test protocols. The interclass correlation coefficient for average values of run distance ($r=0.843$) between results of the first and the second test protocols was ranging from average to very high interrelation [0.724; 0.914], and the correlation ($r=0.510$) was in limits [0.242; 0.706] between results of the second and the third test protocols. The interclass correlation coefficient for indicators of average run speed ($r=0.844$) between results of the first and second test protocols was ranging from average to very high interrelation [0.725; 0.914], and the correlation ($r=0.509$) was in limits [0.241; 0.706] between results of the second and the third test protocols.

The analysis of Blend – Altman for indicators of average HR which were recorded in three consecutive tests, revealed the difference arithmetic average for the first and the second testing -3.53 ± 17.25 . All points on the diagram, except for one entered an interval, limited $\pm 1.96SD$ which borders made [-37.34; 30.28]. The average made 1.46 ± 11.27 for the second and third testing. All points on the diagram, except for one entered an interval, limited $\pm 1.96SD$ which borders made [-20.64; 23.55]. The analysis of Blend – Altman for indicators of average run distance, revealed the difference arithmetic average for the first and the second testing 1.56 ± 9.95 . All points on the diagram, except for three entered an interval, limited $\pm 1.96SD$ which borders made [-17.94; 21.05]. The average made 5.80 ± 18.17 for the second and the third testing. All points on the diagram, except for one entered an interval, limited $\pm 1.96SD$ which borders made [-29.82; 41.41]. The analysis of Blend – Altman for indicators of average run speed, revealed the difference arithmetic average for the first and the second testing 0.026 ± 0.17 . All points on the diagram, except for two entered an interval, limited $\pm 1.96SD$ which borders made [-0.300; 0.351]. The average made 0.097 ± 0.30 for the second and third testing. All points on the diagram, except for one entered an interval, limited $\pm 1.96SD$ which borders made [-0.499; 0.692].

Discussion.

Indicators, which we analyzed, belonged to physiological and space characteristics. In general, they were interconnected and came down to the HR dynamics and the average speed and also distance length of run. T-test which didn't show statistically significant distinctions was used for the assessment of differences of results between testing. Indicators of average HR and its variation, throughout all research, were similar, and distance length increased from measurement to measurement. It can indicate as increase in endurance of examinees, and improvements of mastering run in the offered rhythm that it can indicate improvement of sensomotor synchronization [14]. Our results will be coordinated with C. Karageorghis et al. (2006), which revealed the best

assimilation of a rhythm by the prepared individuals. Decrease in variation for indicators of average speed and distance length of run, also indicates the training effect of the offered testing option. The less coordinate and hardy participants could improve their results, obviously, having raised the extent of following to the imposed rhythm. Thus, the assumptions are confirmed that the individual becomes more economic if acquires the imposed rhythm at execution of cyclic locomotion [17].

In general, the variation of the measured indicators was low and decreased that indicates the sufficient reliability of the presented testing option. Thus, indicators which were recorded during the different periods of testing can be quite comparable.

The Pearson correlation analysis and ICC, which characterize constancy of examinees, showed average force interrelation of indicators, which were recorded during three testing. What is more, correlation coefficients practically matched. The closer interrelation is recorded for space variables that confirm their big reliability and smaller dependence on specific features of examinees in this testing. Physiological indicators, on the contrary, were characterized by smaller correlation and, obviously, a big contribution of specific features of examinees. In general, the correlation wasn't high, but it was reliable that confirms reliability of the presented testing option. Reduction of correlation coefficient at the subsequent testing shows that there is a tendency to increase in individual differences of distinctions in the training activity. Examinees in different degree change the results, despite primary reduction of variation of indicators. Thus, it is possible to speak about a certain level of assimilation of the imposed rhythm at execution of cyclic locomotion that allows improving effectiveness of run. Further, in the conditions of saving of this run rhythm, the effectiveness and efficiency will be depends on individual abilities and ability to implement their (psychology). The reduction of correlation coefficient in the subsequent testing specifies on it indirectly. In general, the research of dynamics of the personal level of the studied indicators will allow estimating a condition of motor function of examinees and profitability of work.

The correlation coefficients were average and high narrowness of communication among testing No. 1-3. It indicates the average degree of recurrence of testing results. Perhaps, it is connected with features of the contingent – the prepared individuals as the group was created from the students-sportsmen having the different level of preparedness without division according to sexual character. It is natural that the endurance of the prepared girls and boys can differ. The endurance didn't change; it is obvious due to the lack of installation on its development, short time between testing. It is indicative that representatives of cyclic sports didn't participate in the research, than and the normality of distribution of results speaks. The correlation coefficients and variation decreased. It indicates the dependence of indicators on the endurance level of examinees. Perhaps, optimum frequencies for movement will also differ at the level variation of endurance. At a certain level of mastering of frequency and development of endurance, specific features can gain a bigger value [5]. Sections of Blend – Altman which showed excellent results of approval on all variables were other factors which confirmed reliability of testing. Mean value of the difference of the studied indicators (Bias) which compared for couples of testing No. 1 – No. 2 and No. 2 – No. 3 was low that demonstrates the lack of systematic discrepancy of measurements for consistently carried out tests. The standard deviation of differences is not too big in comparison with values, i.e. the dispersion degree of indicators isn't big. The research showed a good consent between the indicators received during the different periods of testing.

We consider that the presented option of testing a physical state of the individual has a number of advantages. *Motivation* is connected with restriction of the task [14]. It is necessary to move most effectively, following a metronome rhythm (each blow of a leg corresponds to one beat of a metronome), which increases stepwise. The question of motivation has explicit permission which assumes gradual increase in the measured indicators and also providing a number of compliances: frequencies of a step and frequency of a metronome; average speed of run and HR. Mismatch of these indicators or lack of step dynamics of their increase indicates insufficient motivation or excessive effort. It, in turn, will characterize psychophysiological features of the individual. *Naturalness and informational content*. HR and the general overcome distance and also their interrelation acts as an objective indicator. Space characteristics of run (speed, length and frequency of a step) act as additional indicators. *Profitability*, it is supposed to consider for space features of movement and for power features of metabolism. Having taken the selected frequencies for conditional "standard", it is supposed that execution of run with the offered rhythm will demonstrate the general ability, against the background of the increasing exhaustion, effectively solving the motor problem and to follow a certain rhythm, showing psychophysiological features. Increase in the general distance, when following to a rhythm will demonstrate improvement of characteristics of run, in the conditions of the increasing exhaustion and need to follow a rhythm. At the same time decrease in HR, in the conditions of saving or increase in the general distance of run, will demonstrate increase in profitability and optimization of metabolism. *Technical advantages*. In particular, for the trained runners on endurance, ability to follow the set rhythm will have positive advantages to technical search of improvement of optimum strategy of movement. However, it will have it in a certain framework of specific features of metabolism and anthropometry. *For different population groups*. Following to a certain rhythm at execution of cyclic locomotion of global character which doesn't assume maximum voltage (exhaustion and mental tension) for a wide range of individuals allows estimating physiological reaction and psychophysiological features.

Conclusion.

The presented option of testing allows to provide commonality of a technique as means the identical procedure and conditions of carrying out in all cases of application of the test (the same sequence of actions, stock, measuring devices, etc.). Sufficient reliability and stability of the test as the extent of coincidence of results at the repeated testing, during rather long period (three weeks), had reliable correlations and coherence was shown. According to us, the test has sufficient coherence as the scenario of its carrying out allows providing independence of testing results of personal qualities of the individual who is carrying out the test. Special trends for the studied indicators weren't revealed, except for increase in distance length and speed of movement. It is acceptable for sense of the presented testing and can demonstrate improvement of motivation and understanding of the procedure by examinee that is also desirable. The test has diagnostic and predictive informational content. We consider that it will be possible to increase reliability at more careful selection of groups of examinees and also consecutive use of the submitted test in different population groups. It can be recommended to runners for endurance for assessment of technique features; to other groups of individuals for assessment of motor function condition, profitability and efficiency of movement, psycho-emotional features. The advantage of the test is an opportunity its daily and routine use by coaches and sportsmen, after passing of short instructing on the venue.

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Conflict of interest. The authors declare the absence of any conflicts of interest.

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