Applying non-apparatus and quasi-apparatus tests in a widely understood concept of health promotion – an example of flexibility measurement and assessment

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A Study Design
B Data Collection
C Statistical Analysis
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Abstract

Background and Study Aim: The main aim of the paper is the application of the test as an exemplification of an infinite number of empirical systems, which can be created by individual researchers, physiotherapists or health-related trainers. The study aims at providing the answer to the question whether health-related training based on the exercises of safe falling and avoiding collisions significantly improves flexibility of young men.

Material/Methods: Author's non-apparatus flexibility test. Assessment of flexibility is based on raw result, which is interpreting in general (six grade scale), relatively accurate (ten grade scale) and is calculated with an accuracy of 0.1 the raw result rate. 5 young males, aged between 20 and 23 years were measured before and after 65 and 91 minutes of training

Results: The significant improvement (between 0.6 and 1.9) has been observed in 60% cases. Participants, who revealed very high and high level of flexibility before the training, have not been prone to the stimulus enhancing their flexibility, even though in physiological terms the indicators prove high stimulation of the organism. The effort of both participants has been performed with high intensity (76% and 78% HRmax).

Conclusions: The applied test meets the criteria of the reliable tool for measuring flexibility in every condition, in the safe way and adopted specific assessment criteria are sufficient in the professional diagnostic. The test can be used independently by people of all ages, including blind.

Key words: health-related training • the states of stimulating the organism • flexibility self-assessment • non-apparatus flexibility test

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Background

Henryk Kuński, a leader of health promotion in Poland, generally believes that health promotion in Poland is a process of implementing changes in the way and conditions of living in order to improve and develop health and keep it under constant supervision [1, p.14]. Two assumptions are enthymeme assumptions in this broad definition. The first one stating that most important areas of modern human being activities i.e. family life, education, professional activity, nutrition and leisure activities generate patterns of behaviour, which often result in deterioration of all aspects of health i.e. somatic, psychological and social. Secondly, a large number of unemployed and illiterate population are burdened with lack of possibility to influence their health and other people, whereas their living conditions create usually favourable conditions for deterioration of all aspects of health. Therefore, the alternative definition of health promotion should read as follows: *health promotion is a process of lifelong continuation of behaviour patterns acquired during compulsory education aiming at improvement and development of health, whereas a fundamental condition of maintaining or improving health is a habit of constant monitoring its condition*.

Motor safety – is consciousness of the person undertaking to solve a motor task or consciousness the subject who has the right to encourage and even enforce from this person that would perform the motor activity, who is able to do it without the risk of the loss of life, injuries or other adverse health effects [21].

This definition would be correct only with reference to a certain group of people who are or were fortunate to participate in elite education.

Both the analysis of a subtle difference between definitions and discussion on the consequent implications are omitted in this paper. The attention is focused on a common element i.e. the necessity of constant monitoring of health status. Scientific papers and implementations concerning somatic health dominate in well-established tradition of health promotion. No wonder, since this aspect of health is of fundamental importance in our daily activities.

The issue of questionable effectiveness of people, whose work requires optimal coordination and functional capacity, is being mentioned in the discussion concerning the need to extend retirement age. Not only the effects of business activity are a measure of capacity to function in an optimal way. Empirical argumentation proves the fact that people in this age are particularly vulnerable to events increasing the risk of health damage or even life loss. Epidemiology of numerous diseases (including civilisation and occupational diseases) related to age is left aside, because progress in medical science and favourable changes in lifestyle may significantly reduce the risk of the aforementioned diseases as well as eliminate habits resulting in health deterioration and life hazard. The issues underestimated in the area of daily activities of thousands of people regardless of their age are emphasized in this paper. Everyday reaching and returning from work are inevitably linked to accidents resulting even in loss of life. Due to the deterioration in psychomotor performance of people over 65, there is a high probability that the number of deaths and injuries occurring during moving between home and work will increase among this group. People in this age can become perpetrators of a growing number of traffic accidents both as a driver or a pedestrian. According to World Health Organisation [2] the most common cause of unintentional deaths throughout the world lies in traffic accidents, whereas second largest cause is falls (annually circa 424 000 falls are fatal and people over 65 are the most vulnerable group). The results of several studies [3,4] reveal that 40% of older people who have fallen are not able to raise oneself. One of the main factors increasing mortality after a fall is remaining in horizontal posture for at least 1 hour [5].

Thus, the primary issue of widely understood health promotion is to increase motor safety of the elderly. In particular, the attention should be drawn to limit the number of falls and the effect of the collision of the body with the ground or vertical obstruction.

At least three significant areas of human activities related to falls can be distinguished: during moving between home and work (or education institutions), while performing professional activities and in other circumstances. In climatic zones piled with snow or black ice during several months, a risk of injury resulting from a fall periodically increases several times. It was during the black ice on 13 November 1993 when 86 required interventions of the Regional Ambulance Service in Wroclaw (Poland) was five or even ten times higher if compared to sunny days [6]. Epidemiology of injuries due to falls in the workplace is carefully monitored [7]. Similarly, in other circumstances – at home, social care centres, during sports activities, a hospital stay, etc. [4,8].

The effectiveness of falls' prevention can be ensured by strength and balance training, elimination of domestic risk factors, improving the ocular function, functioning of circulatory system, mental functions and verification of drugs used [8]. Lack of adequate strength, especially of leg muscles, capacity to make kinaesthetic differentiation and flexibility cause that a person losing balance is not able to optimally direct various body parts during a fall and afterwards during the collision of the body with the ground or vertical obstruction. These shortages together with lack of ability to cushion colliding body with the ground or an obstruction constitute a major cause of injuries or even death.

Basic premise of empirical and cognitive parts of this paper is that motoric test (exercise endurance test) of the required reliability (accurate and reliable), which use does not require even the simplest instruments or can be conducted with simple instruments (a stopwatch, a ruler, a measuring tape, etc.), are the most useful for physiotherapists and health-related trainers, especially of the elderly as well as each person interested in self-evaluation of morpho-functional capacity. The first category includes **non-apparatus tests**, while the second one **quasi-apparatus tests**. The following assumptions are as important: (i) a measuring instrument is not anything used during a motor test (e.g. a medicine ball, a bar, a boxing bag); (ii) a thing, which use is a prerequisite both of exposure of a given category of physical activity and reading the rate of this exposure, is eligible for being a tool for **apparatus tests** (e.g. dynamometer, cycloergometer).

The main goal of the paper is to justify the usefulness of non-apparatus flexibility test of the lower spinal region and hamstrings along with the standards for assessment developed by the author. The aim of empirical part of the paper is the application of the test as an exemplification of an infinite number of empirical systems, which can be created by individual researchers, physiotherapists or health-related trainers. The study aims at providing the answer to the question whether

Figure 1. Example of measured flexibility (results below the determined line).

Figure 2. Initiation of detailed measurement (from *dactylion III* to determined line).

health-related training based on the exercises of safe falling and avoiding collisions significantly improves flexibility of young men.

Material and Methods

Measurement of the flexibility of lower spinal region and hamstrings

The manual of non-apparatus flexibility test

Sit in a straddle position (with legs apart for a foot length) so that the heels are adjacent to the previously **determined line** i.e. linking *tuber calcanei* of both feet. Put one hand in the middle of the knees with fingers directed towards the feet and the second one place from the top. Hands joined in his way press lightly down to the ground. Straighten the legs in knee joints and slowly do a forward bend moving the hand on the ground to the area in which you will be able to hold them for 2 seconds tolerating negative feelings generated by the extension of the body (Figure 1). Without changing the position of the hand bend your knees, sit back and estimate the result.

Assessment method

If the end of distal phalanx of the middle finger (*dactylion III*) coincides with the determined line, then so-called raw result equals **'0'**. If the determined line coincides with the palm line set as a furrow connecting *stylion radiale* and *stylion ulnare*, the result equals **'1+'**. This indicator means that the person's flexibility with respect to the reference system (determined line) is surpassed by the length of the palm. When the result is estimated between **'0'** and **'1+'**, it is determined every '0.1+' (basically, this value corresponds to the width of II, III, IV finger), e.g. **'0.7'**. Therefore, the result exceeding **'1+'** is determined e.g. with the value **'1.3+'** (corresponding to the length of the palm and a total width of II, III and IV finger). Similarly, each result is estimated every

Figure 3. Continuation of the detailed measurement (in this example the raw score '0.5–' indicates the relatively high level of flexibility).

'0.1–' in case when *dactylion* III does not coincide with or exceed the determined line (Figures 2, 3 exemplify the result of '0.5–').

Criteria for assessment

The overall level of flexibility of the lower spinal region and hamstrings is referred to six-point scale (Table 1), each with attributed value of so-called raw result: very high flexibility 5 points (result **'1+'**), high flexibility 4 points (**'0'**), average flexibility 3 points (**'1–'**), low flexibility 2 points (**'2–'**), very low flexibility 1 point (**'3–'**), insufficient flexibility 0 points ('**≤3.1–**'). Ten-point assessment scale is used to estimate relatively accurate level of flexibility. Designated range of results enable the estimation of the level of this feature with an accuracy of 0.1 (facilitated by the indicators of a raw result). Thus, for example raw result '8+' precisely calculated will be determined as 4.8, meaning very high level of flexibility in an adopted range (general indicator **'5'**). If e.g. raw result '2.2–' is determined as 1.8, meaning low level of the feature both when estimating general level

Table 1. Indicators and norms of flexibility of the lower length of the spine and hamstring tendons on the basis of the non-apparatus flexibility test results.

Relatively precise level of flexibility	Indicators of flexibility			General level of flexibility
	Assessment of ten grade scale	Raw result	Assessment of six grade scale	
	5	**≥1.0+**	**5**	Very high
Very high		0.9+		
		0.8+		
		0.7+		
		0.6+		
Relatively very high	**4.5**	**0.5+**		
		0.4+		
		0.3+		
		0.2+		
		0.1+		
High	**4**	**0.0**	**4**	High
		0.1–		
		0.2–		
		0.3–		
		0.4–		
Relatively high	**3,5**	**0.5–**		
		0.6–		
		0.7–		
		0.8–		
		0.9–		
Average	**3**	**1.0–**	**3**	Average
		1.1–		
		1.2–		
		1.3–		
		1.4–		
Relatively average	**2,5**	**1.5–**		
		1.6–		
		1.7–		
		1.8–		
		1.9–		
Low	**2**	**2.0–**	**2**	Low
		2.1–		
		2.2–		
		2.3–		
Relatively low		2.4–		
	1,5	2.5–		
		2.6–		
		2.7–		
		2.8–		
Very low		2.9–		
	1	**3.0–**	**1**	Very low
Insufficient	**0**	**≤3.1–**	**0**	Insufficient

Table 2. Age, indicators of somatic development, flexibility and level of stimulation of the men organism (n=5) before (A), after 65 minutes (B) and after training (C).

Code the person	Age/years	Somatic development			Flexibility [raw score]						Stimulation of the organism [HR]		
		Body height [cm]	Weight [kg]	BMI	Result in the period of measurement			Differences in results					
					A	B	C	A–B	A–C	B–C	A	B	C
R1	23	178	80	25.25	1.0+	1.0+	1.0+	0.0	0.0	0.0	70	157	152
R2	22	182	70	21.13	0.3+	0.9+	0.9+	0.6	0.6	0.0	72	131	131
R3	21	187	70	20.02	0.0	0.0	0.1+	0.0	0.1	0.1	90	156	150
R4	20	192	92	24.95	0.5–	0.0	0.1+	0.5	0.1	0.6	82	137	136
R5	21	180	90	27.77	1.0–	0.9	0.8	1.9	1.8	0.1	76	165	157

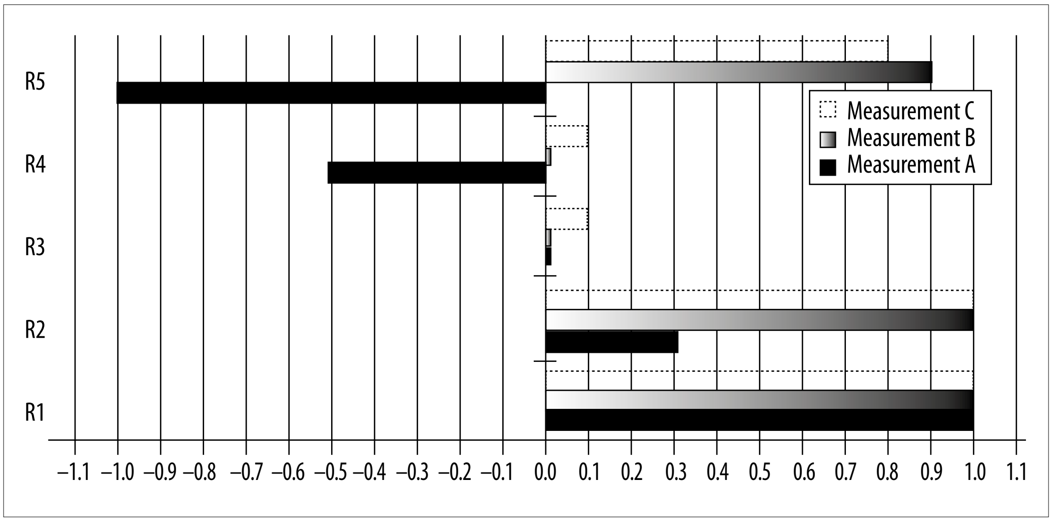

Figure 4. Flexibility of young men (n = 5) estimated by the raw result rate before (A), after 65 minutes (B) and after training (C)

of flexibility ('1') and relatively accurate level. Using only six-point scale, raw results e.g. '0.4+' and '0.2–' will be intuitively interpreted as high level of flexibility.

Raw result larger by at least '0.3' (regardless of the sign) with respect to the result obtained before starting the safe fall exercises (A) is considered to be a criterion of 'significant improvement in flexibility'. Second measurement of flexibility was performed after 65 minutes of exercise (B), while third after the training (C) i.e. after 91 minutes. Raw result of various persons' flexibility, starting from the one (R1 code etc.), which result indicates higher level of the feature during measurement A, is assumed as an ordinal variable in the presentation of empirical data.

Measurement of the states of stimulating the organism

Identification of the states of stimulating the organism is based on two indicators i.e. duration and intensity of the effort. Duration of the exercise (entire effort and exercises preceding measurement B) is measured in minutes. Intensity of entire training and exercises preceding measurement B is determined with an average pulse intensity (HR). The respondents have palpably checked their HR for 6 seconds repeatedly during the breaks between exercises. This method is optimal during safe falling exercises (the necessity to perform multiple dynamic cushioning impacts with the arms excludes using pulsemeters). The interpretation of the intensity of the effort (converting HR to 1 minute) is based on the intensity zones according to Pollock et al. [9].

Statistical analysis

Range, arithmetical average and standard deviation of flexibility indicator estimated to an accuracy of 0.1 of raw result calculated over ten-point scale of results. The significance of the difference between two averages for correlated samples (A–B, etc.).

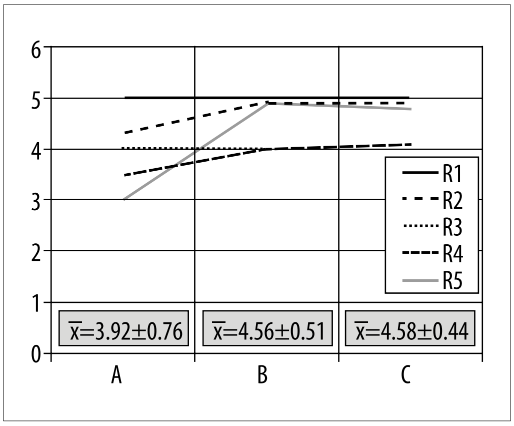

Figure 5. The level of flexibility of young men (n = 5) before (A), after 65 minutes (B) and after training (C) estimated with an accuracy of 0.1 the raw result rate (calculated on a ten grade scale)

Participants

5 young males, students of recreation, aged between 20 and 23 years with substantially different somatic development (Table 2), who have regularly once a week participated in health-related training. Their ability to accurately measure HR and record the effort has been verified before the study. Students have acquired the knowledge and skills during 15-hour lecture and 30-hour health-related training based on so-called exercises improving general body condition. The measurement of flexibility has been performed in the following semester during the fourth classes of safe falling and avoiding collisions course (i.e. specific type of modern health-related training).

Results

The majority of the participants (80%) experienced the improvement of flexibility (between 0.1 and 1.9 raw result) after 65 minutes of safe falling and avoiding collisions exercises, whereas a significant improvement (between 0.6 and 1.9) has been observed in 60% cases (Table 2, Figures 4, 5). A participant marked with R5 code has experienced the greatest improvement of his flexibility after his period of exercises (raw result 1.9) and has basically kept the result until the end of the training. His training has been the most intensive (HR of entire training 157; 167 during first 65 minutes i.e. 85% of HR_{max}). Likewise, participant R2 has improved his flexibility after 65 minutes of effort, but to smaller degree (0.6), and has kept this state until the end of the training. 65-minutes exercises has become a significant stimulus of flexibility (improvement of 0.5 raw result) and during further effort the range has been increased by 0.1 of raw result.

Participants, who revealed very high (R1) and high (R3) level of flexibility before the training, have not been prone to the stimulus enhancing their flexibility, even though in physiological terms the indicators prove high stimulation of the organism. The effort of both participants has been performed with high intensity (76% HR_{max} in R1 and 78% HR_{max} in R3; 82% HR_{max} and 81% HR_{max} respectively after 65 minutes of training).

Range, arithmetical average and standard deviation of the results calculated over ten-point scale indicate that the level of the feature has most evidently revealed after 91 minutes of training (measurement C) (Figure 5). Range measured with raw result has amounted to 2 during measurement A, whereas to 0.9 during measurement C. Standard deviation (±0.44) proves the smallest individual variation. The differences of flexibility level between particular measurement stages are not statistically relevant within the meaning of the average result.

Discussion

Anglo-Saxon literature defines flexibility as the '*Ability to move joints smoothly through complete range of motion without injury*' [10, p. 382]. Non-apparatus test presented in this paper belongs to the tests evaluating dynamic flexibility [10, p. 245–63]. The results, however, cannot be referred to other studies due to the pilot use of the test. Nevertheless, empirical arguments are sufficient to perform critical analysis of the test compared to tests recommended for flexibility assessment of lower spinal region and hamstrings.

In terms of motoral similarity to other test with the same designation, it is closest to the recommendations of the American College of Sports Medicine [11], Canadian Society for Exercise Physiology and various research teams [10, p. 254–57]. All tests are performed while sitting on the ground: *Standard Sit-and-Reach Test*; *Modified Standard Sit-and-Reach Test*; *V Sit-and-Reach Test; Back-Saver Sit-and-Reach Test*. Certain similarities exist in the system of assessment. General assessment of flexibility in *Standard Sit-and-Reach Test* is based on five-point scale, whereas in *V Sit-and-Reach Test* on ten-point scale. A fundamental difference, however, lies in the fact that the aforementioned tests require using special box provided with measuring tape on the top. Hence, they are quasi-apparatus tests.

Non-apparatus flexibility tests with the same or similar designation bear more similarities. In terms of general concept and principles of assessment, the most similar will be *self-assessment bending scale (SABS)*, which is an alternative to *finger-floor distance (FFD)*. Correlation of SABS and FFD results is very high (r=0.95) [12]. The test is, however, performed in standing posture and consists of forward bending with straighten knees.

Seven-point scale of SABS starts from 1 point (fingers do not reach below the knees) and ends with 7 points (palm reaches the ground). Raw result '**1+**' of the test presented by the author corresponds to 7 points in SABS, whereas '**0.5+**' is identical to 6 points (all fingers reach the ground) in SABS scale. The most important limitation of SABS is the risk of applying the test in assessment (self-evaluation) of people exhibiting dizziness, balance disorders and other neurological conditions. SABS can be burdened with significant error during flexibility self-evaluation performed by visually impaired persons.

The limitations listed are not the factor in proposed non-apparatus test, which should be performed in sitting posture. Students of physiotherapy, who I prepare to teach blinds safe falls (many exercises are done with eyes covered), can precisely use this test and confirm its high usefulness. Moreover, the main advantage of three possible scales of flexibility assessment while using this non-apparatus test is elimination of negative values. The greatest benefits should be attributed to the possibility of transformation of ten-point scale to a measurement within an accuracy of 0.1 raw result (in fact of approximately width of any of II, III or IV finger). This revised scale is useful for more precise flexibility assessment (Table 1). Results can be easily transformed for T-scale or more precisely used in data transformation procedure to arithmetic average and standard deviation.

Seemingly, it seems reasonable to express criticism that width of fingers of particular people differs so diagnostic value of the test remains questionable. A major counter argument will be based on the fact that indicators of positive health, which are relativized for a certain person, should not be interpreted similarly to indicators used in sport (they are expressed in absolute values i.e. kilograms, meters, seconds, etc.) to document life, national, Olympic records, judge competitions or to precisely define qualification criteria to a given category of sport competition. Nevertheless, measurement of positive health based on the SI system or other measures seems necessary. On the contrary, the variety of health measures is a consequence of many factors, but the most important criterion required is diagnostic sufficiency. Although flexibility is a property of an organism and from rehabilitations or self-evaluation view its determination does not require precision required e.g. in surgery or ophthalmology, assessment of this feature in too wide ranges hinders observation of good effects. Moreover, it may trivialize mental effects of training which are related to general well-being of a person, motivation, awareness of the meaning of exercises, constant self-control, etc.

Together with other morpho-functional indicators, flexibility determined according to the criteria proposed herein are sufficiently precise to correctly assess suitability for a certain occupation. Provided that certain recommendation requires very high level of flexibility, then regardless of candidates' age and actual length of his hand (i.e. measured in centimetres) he will meet the criteria if the raw result will account to '≥1+'.

Following this line of reasoning, it will be justified to conclude that a fundamental criterion for any non-apparatus or quasi-apparatus test for self-evaluation is their easy and safe use. Their application in rehabilitation and health-related training is determined by diagnostic value. Non-apparatus flexibility test presented in this paper fulfils the expected criteria for usefulness in self-evaluation (broadly understood health promotion) and more challenging professional diagnostics.

Non-apparatus tests are the most useful in self-evaluation due to the fact that there is neither the need for participation of other people nor the use of additional instruments. The test presented herein can be safely used at home, in the garden, in bed, etc. Wide application of tests from this category concerns people remaining in long motoral isolation. For example young males (19.08±0.6 years old) remaining in prison for 1–2 years have worse somatic development than their peers playing ice hockey and simultaneously the percentage of fatty tissue is higher [13]. The most significant mission of penal institutions is resocialization of inmates, therefore main issues concerning this mission include promoting awareness of positive health self-evaluation and the need for maintaining physical fitness on an optimal level. This should result in a complex of educational and logistic actions (recreational infrastructure) so that as high number of inmates as possible could take work in the future knowing that they fulfil relevant health criteria. The role of non-apparatus tests of physical fitness cannot be underestimated in this field.

Circumstances of applying non-apparatus or quasi-apparatus test in rehabilitation and health-related training generally are more complex. In this paper two issues are emphasized i.e. the inevitability of extending economic activity and increase of falls and collisions with various objects during professional activities or reaching and returning from workplace in the population of 65-year old people and older. The use of non-apparatus test with this diagnostic values represents one of the examples of making aware not only the elderly to what extent they are susceptible to body injuries during falls [14]. The test may be applied at a doctor's or rehabilitation office, at the place of health-related training, in the garden, at the beach, etc. Prerequisite for performing the test would include soft ground (foam mattress or mattresses, mats, sand, etc.), knowledge of test methodology and ability of interpretation the result. If a given specialist explains carefully the mistakes of a tested person during possibly fast change of posture from vertical to horizontal (simulated fall), the recommendation to repeatedly perform each tasks of the test enabling conscious control of the movements of particular body parts and eliminating the mistakes constitute the first important step towards individual learning of safe collision with the ground. After standing from the ground without leaning on the arms, the importance of flexibility, strength of abdominal, trunk or legs muscles and general coordination is emphasized. Further education of safe falling should take place under specialist supervision. Motoral competencies in this field are diagnosed with use of non-apparatus [15,16] or quasi-apparatus tests [17,18]. Incidentally, according to Sterkowicz research [15] young males, who have been proven the skill of safe falling, have had greater strength of leg and abdominal muscles and flexibility as well.

The above-mentioned description is a simplified exemplification of a complementary use of non-apparatus (quasi-apparatus) test in health prophylaxis including diagnostics of motor abilities (condition and coordination) which determine stability of the posture and are relevant in falls prevention of the elderly [19].

In this discussion it would be misguided to claim that sophisticated measurement methods of positive health have no sense because of the cost of instruments used. In contrast, it is precise measurement of certain motoral abilities in various conditions that is essential in cognitive sense and may be inspirational in terms of application [e.g. 20]. The author believes that verification of suitability of non-apparatus and quasi-apparatus tests by correlating obtained results with results obtained by apparatus tests, which in intersubjective opinion of experts accurately measure given morpho-functional abilities of a person, to be the most rational research perspective.

Conclusions

The test fulfils the criteria of reliable instrument serving for flexibility measurement in every condition in a safe way and specific criteria of assessment are sufficient in professional diagnostics. Test may be used independently by people all ages including those visually impaired.

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