Methodology of measurement, documentation and programming of optimal continuous workload with variable intensity – applications in sports medicine, physiotherapy, geriatrics, health-related training and sport for all

Authors' Contribution:
A Study Design
B Data Collection
C Statistical Analysis
D Manuscript Preparation
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Abstract

Background and Study Aim: Continuous effort can be defined as the activity of every muscle since the impulses of any intended movement aiming at implementation of a given goal result in an increase of heart muscle contractions beyond resting heart rate until the end of a given activity. The goal of this paper is the methodology of measurement and documentation of continuous physical effort with variable intensity.

Material/Methods: Methods used in the study included the Delphi method, analysis of the literature and scientific documentation, participant observation, case study and designing elements. The analysis of over 3000 reports of researches performed by students of physiotherapy and recreation (n=855) during standard health-related training including those based on the exercises of safe falling and avoiding collisions (participant observation) was conducted in 2008-2012.

Results: The considerable advantage of the methodology of measurement, documentation and programming of the workload presented herein is the possibility to express this variable with the use of universal index, referred to as **LE** and based on conventional units. The index can be used at any level of preliminary analysis i.e. from particular exercises and set of exercises, training sessions to microcycles, mesocycles, macrocycles and long-term cycles.

Conclusions: The reduction of health promotion and physical activity mainly to walking, running, cycling or other simple forms of exercise may *counterproductive* in the longer term. That is, instead of achieving the ultimate goal of common physical activity we will achieve its negation.

Key words: effort safety • intensity zones • judo • supramaximal efforts • test for safe falls

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Background

Physiological perspective

It is no use to create general division of physical effort to continuous and intermittent, if there is no frame of reference and precise definitions. If professional activity is assumed to be the frame of reference, few positions can be named which require constant muscle activity. It is easy to enumerate occupations with one-time physical effort lasting even several hours e.g. a miner, construction worker, truck or tour bus driver, soldier from

Continuous training – one continuous, aerobic exercise bout performed at low-to-moderate intensity [6].

Discontinuous training – several intermittent low- to high-intensity aerobic exercise bouts interspersed with rest or relief intervals [6].

Supramaximal efforts – can be defined as efforts with oxygen demand exceeding VO2max [16].

MET – metabolic equivalent.

Effort safety – is consciousness of the person who starts physical effort or consciousness of the subject who has the right to encourage or even enforce from this person the physical effort of a certain intensity and duration, who it is able to do so without risking life or health [17].

Playing tag – by name – pupil or pupils with name called by the trainer become 'hunters' and have the right to slap symbolically the backs of other participants with their hand or the kimono belt – the opponents are to avoid such contact (this goes on until another name is called or the signal 'stop' is given) [35, p. 24].

Limping fox – from a 'burrow' delimited in the corner of the mat the pupil tries to touch with kimono belt (or hand) one of pupils running away on both legs, while he limps only on one; until the touched person has not reached the burrow, the remaining ones have the right to hit him in a symbolical way only on the back; once he has reached the burrow he assumes the role of the *limping fox* [35, p. 30].

particular unit, etc. Such professions usually involve the necessity of repeating even several long-lasting efforts during a day.

Sport, health-related training and rehabilitation offer more specific examples. One-time long-lasting sports include e.g. a marathon as well as long-distance cross-country skiing, swimming, race walking, a stage of bicycle racing, etc. Athletes perform such efforts only once during a day or even in intervals lasting multiple days or weeks (marathons). Occasionally, there are some exceptions to this rule, e.g. two stages of bicycle racing during a day. On the other hand, numerous sports disciplines involve a one-time continuous physical effort lasting from few seconds to couple of minutes (racing competitions including sprint, swimming, cycling, skiing, tobogganing, etc.). However, an athlete is required to repeat the efforts at least twice a day during competition. The triathlon represents a typical example of sport involving three continuous efforts performed one after another in various environmental conditions, the longest stage being cycling (standard distance: 1.5 kilometres swim ÷40 kilometres bike ÷10 kilometres run).

Continuous efforts are recommended as the optimal means of health-related training and rehabilitation (especially cardiac, with necessary precautions taken) mainly of adults and the elderly [1–7]. In professional sport they are essential to develop physical fitness (during the preparatory phase of the mesocycle) and to maintain its optimal level by a given athlete during the competitive phase of the mesocycle (taking into account the nature of the sport). Some sport theorists group continuous efforts into efforts with constant and variable intensity. In general, such distinction is drawn during the description of training methods and this view has not changed since many years [8–10]. In practice, it is very difficult to maintain an effort with constant intensity for a longer period of time. Hence, the division of continuous efforts (for the purposes of workload assessment in any activity) into those having relatively constant and variable intensity is more accurate.

The author defines continuous effort as every activity of skeletal muscles together with all functional changes occurring in the body since the impulses of any intended movement aiming at implementation of a given goal result in an increase of heart muscle contractions beyond resting heart rate until the end of a given activity. While assessing the workload according to this definition, the extent to which the goal was achieved in praxeological meaning (efficient/inefficient) has been disregarded due to given external criterion e.g. the number of accurate throws to the basket. The association of the physical effort assessment as physiological stimulus with praxeological assessment or any other assessment may follow from the realisation of specified equivalent goals of a given activity, e.g. with ethical assessment (commendably/disgracefully) if the effort in question is basketball match. This issue, however, falls outside the scope of this paper.

One-time continuous effort may involve moving the wardrobe on the floor even for a few centimetres as well as a 5-kilometer run on the tartan track. In given circumstances (external e.g. wardrobe weight, slipperiness of the floor and internal e.g. exertional capacity, motivation) moving the wardrobe for a few metres may necessitate multiple dynamic efforts with predominance of isotonic contractions and short-lasting isometric contractions or efforts being alternately dynamic and static (longer isometric contractions). If the intervals between successive impulses are short, this would constitute the logical and factual (related to effort biochemistry and physiology) basis to classify this muscle activity as continuous effort with variable intensity. Basing on the recommendations of physiologists, training theorists and experienced trainers it can be assumed that continuous effort with variable intensity is every muscle activity lasting for at least several minutes given the fact that the interval between active phases of activity consistent with its goal does not exceed one minute during an activity with maximum intensity and 30 seconds during an activity with vigorous or moderate intensity.

The argumentation based on empirical data may serve as substantiation of this general assumption. Wolkow [11] recommends that the training focused on the endurance development of young athletes should involve rests lasting from 60 to 90 seconds between 10 to 20-second exercises with maximum intensity (HR >170 bpm). He also recommends 6–7 repetitions per set in the 'activity-rest' training programme. The rest between 20–120 second exercises with vigorous intensity (HR 151–170 bpm) should last from 30 to 60 seconds (6 to 7 repetitions per set). The same rest is recommended by Wolkow between exercises with moderate intensity (HR 130–150 bpm) lasting 120–180 seconds, however the number of repetitions per set should be reduced to 5 or 6. Therefore, the recommendations of Wolkow refer to intermittent effort in contrast to continuous effort with variable intensity defined above.

Furthermore, Wolkow have also established that restitution dynamics after the effort with maximum intensity in females and males aged 10–15 years is characterized by slight differentiation related to sex and age [12]. Basing on the average results, he has noted significant regularities. HR after the first minute of rest indicates that the state of body stimulation corresponds to the effort with moderate intensity (HR decreases from 17% to 25% in females and from 20% to 22% in males compared to the state immediately after the effort). After second minute of restitution the difference amounts to 27–33% in females and 29–31% in males. According to the classification of workload intensity adopted by Wolkow the stimulation of the body after the second minute of restitution corresponds to low intensity zone.

According to the criteria of constant effort with variable intensity presented in this paper, HR in females and males aged 10–15 years may be assumed to decrease more than 20% during the rests between subsequent phases of muscle activity with maximum intensity. Under this assumption the generalization can be made that similarity to the metabolism prior to the rest is maintained during short rests between exercises (muscle activity). Both in the theoretical and practical sense the issue of intensity of the next exercise or specific effort related to any work (paid, rescue, or forced by other circumstances) remains open. However, if the goal of a given training, physical education class, rehabilitation, etc. is to practice continuous effort with variable intensity, the duration of rest after each effort can no longer remain an open question. It is essential to respect the 'activity – rest' criterion.

Since various scientists recommend different scales for estimating the workload and in spite of numerous similarities, the conclusions drawn in the last paragraph of the paper are justified in so far as the data observed would be referred to specific criteria. For example, during the observation of physical effort (game involving physical movement) in children aged 3–5 years Jaskólski et al. [13] recommend a method for workload estimation developed by Japanese professor Kacube, which specifies that 160 bpm HR corresponds to high, 159–130 to moderate and 129 to low intensity.

It is common to use more workload intensity zones (exercise intensity) for both young people and the adults. The suggestion of Swaim ad Edwards [14] concerning young people is based on five zones of HRmax percentage i.e. (1) 50–60% (under 119 bmp); (2) 61–70% (120–139 bmp); (3) 71–80% (140–159 bmp); (4) 81–90% (160–179 bmp); (5) 91–100% (180 BMP and above). Moreover, average energy expenditure measured in calories per minute was assigned to each zone. It amounts to /5/ /5–8/ /8–10/ /10–15/ /15–20/ respectively. As the basis for HRmax calculation Swaim and Edwards recommend the Ball State University formula, where the HRmax for females equals 209 – (0.7 × age) and for males equals 214 – (0.8 × age).

The classification of workload intensity in adults developed by Pollock et al. [15] is based on six zones. Both classifications are useful in the interpretation of continuous efforts with intermittent intensity. However, reasonable recommendations concerning the effectiveness of continuous efforts with intermittent intensity in broadly understood health promotion and prophylaxis should include not only the exercise intensity but also their duration, frequency, rate of progression, stages of progression [6] and other factors.

In the general introduction to physiological classification of physical efforts, Kozlowski et al. [16] emphasize the fact that the description of processes occurring in muscles and other organs operating during the effort is conditioned by the type of muscle contraction, the size of muscle groups active during the effort, the duration of the effort and workload intensity. This statement is complemented by two fundamental observations made by Bullock et al. [4] on physiological consequences of the effort i.e. the influence of the training can be observed only in the muscles involved in the activity; it is the isotonic effort only that may prevent cardiovascular diseases.

The field of the training theory, praxeology and systems science

From the perspective of thoughtful consideration of all dimensions of health (somatic, mental, social) and the need for survival rather than the training theory, it follows that the influence of training should not be associated only with its physiological aspect. References should be made to other body systems (especially the nervous system) and mental sphere [17,18]. Moreover, the critical analysis of the physical efforts classification recommended by physiologists leads to conclusion that the variety of indicators and standards applied to the estimation of workload may be justified by at least two reasons. First of all, the knowledge of the human adaptation to exercise still remains an open question. Secondly, the recommendations are usually grounded on the adopted research assumptions and research methodology applied in relation to the goal of the effort (the zone is broad from the rehabilitation of the hardest cases to extreme sports). Therefore, the significance of optimization of the methods for workload measurement and documentation of the results is still growing. In other words, monitoring of this phenomenon is becoming even more essential.

Since sport became a crucial part of political confrontation of two systems and afterwards the possibility of fast enrichment of the athletes, it appears that it needs indicators which would enable reliable and accurate workload monitoring. Long-term career oriented towards success in the atmosphere of growing competitiveness (high number of starts, pressure to establish new records,

Act like a snak – A lies on his back, B lies with his front to him (in a transverse way) and immobilizes movements without possibility of pressure of the hands on his body; at a signal given by the referee B tries to change his position to lying prone, but also cannot exert pressure on the body of A with the hands (Fig. X) – change of roles after three attempts; evaluation criteria: 1 point for each holding of the opponent in lying on the back for 5 seconds [35, p. 32].

Matador – A has arms outstretched in front (hands placed one over the other and directed towards the centre); he takes off for a run over a section of 3–4 metres and tries to touch the chest of B with his hands; B avoids contact for example by shifting the left leg right to the rear, and simultaneously by making a semi-turn on toes of the right leg, to turn to face the direction of the run of A [35, p. 39].

Randori (...) Sparing in jūdō in which both participants practice attacking and defending [50].

Test for safe falls – The test comprises execution of four consequent tasks constituting a series of seven falls: 1. rear fall and rear fall with turn; 2. front fall; 3. fall to the side (left and right); 4. front fall with turn over the shoulder (left and right) [34, 35, see also Safe Falls Academy in Archives of Budo (video)].

Counterproductive action – the action is counterproductive when a doer achieved the opposite of intended goal [51, p. 220].

tempting rewards, etc.) favours mainly people talented at given motor fitness as well as those able to tolerate extreme physical efforts, both intensive and frequent (see one of the conclusions from most recent research [19]).

The finding that the necessary condition for obtaining the desired form during the most important sports competitions is the ability to accurately determine a relationship between performed muscle activity in quantitative sense and the intensity of the effort. This was one of the major discoveries made in the mid-1900s. It has forced the necessity to develop the indicator with higher level of generality, but still precise enough to provide reliable data about the relationship in question [20–23]. Intensification of the exercises requires longer rests and thus the reduction of repetitions of a given exercise or exercises during a training determined a priori (usually arbitrarily). On the other hand, the greater number of repetitions is determined by the decrease of isotonic contractions. In both cases, programming of the duration of particular training sessions is as essential as respecting safe zones of workload intensity. The control over both factors is a basic procedure to influence safety effort of a particular human being [17]. An increase in the exercise duration to reasonable limit and determination of the duration of rests between exercises is limited by individual capabilities. Therefore, the knowledge about those capabilities, which are highly sensitive to many factors e.g. total effects of training, nutrition, general physical and mental state, momentary or temporary incapacity, etc., should be associated with current effect of the exercises to the body. In the theory of training this indicator is referred to as the *training load* (in broader terms as *workload*) and is defined as the amount of work performed during a training unit (training session) in the microcycle, the mesocycle, the annual cycle and long-term training. In general, quantitative factor is a total evaluation of the training components that are distinguishable in a given exercise category. To put it simply, the intensity of the effort can be perceived as qualitative factor.

A simple mathematical model of training load can be defined as the product of qualitative and quantitative factor. This reasoning may became unclear whenever the quantitative factor is called 'workload volume' or 'training volume' [8–10,20–23] interchangeably with 'volume of physical activity' [6]. Various units have been adopted as measures i.e. the number of repetitions, kilometres, tons, kilocalories, etc. as well as various units of time (seconds, minutes, hours). Although in the training experience and scientific analyses, the time is assumed to be the most general measure of this volume, in academic textbooks, research and methodological papers the term 'workload volume' and its synonyms have not been supplanted by any adequate term. Radoslaw Laskowski goes even further and adopts time as an indicator of *training load* in long-term judo training of females for three types of efforts: comprehensive (W-), targeted (U-) and special (S- symbols correspond to the Polish names of this terms) [24].

As in the real world nothing happens beyond the time, the basic procedure of improvement of workload measurement should logically start with separation of the time factor from the set of phenomena so far classified together as '*workload volume*'. It is difficult to provide a direct evidence that this was the fundamental assumption of the creators of *training load* measurement methods in combat sports and games [23,25–29]. They have usually adopted time as the *workload volume* indicator. Due to the fact that the heart rate (HR) is commonly accepted as the universal measure of workload intensity, the product of effort duration and HR seems to be the general indicator of *training load* defined as the amount of workload. It is useful in analyses with a high level of generality. If it should serve as a tool for many specialists and be a subject to further calculations, detained indicators such as multiplicand and multiplier should be established and accepted. Then what basic indicators are binding for the multiplicand i.e. effort duration? Seconds, minutes, hours? What unit of measurement should be adopted for the multiplier i.e. in what interval should HR be measured (20-, 15-, 10-, 6 seconds)? In current research and training practice the product of effort duration and HR was referred to as 'conventional units' [28–30] or further calculations have been made to convert it into points [23,26].

If such assumptions are accepted, the remaining and very important workload indicators should be precisely measured and documented in order to use them for the benefit of more detailed analyses. Due to the limited space, the relationship between physical effort and respiratory reactions will not be discussed. This issue had already been widely discussed in scientific literature.

Study Aim

The main goal of this paper is the methodology of measurement, documentation and programming of optimal, continuous physical effort with variable intensity. Application goal are recommendations for sports medicine, physiotherapy, gerontology, health-related training, sport for all as well as its use by everyone who cares for their own health and the health of their loved ones.

Material and Methods

Methods: the Delphi method, analysis of literature and scientific documentation, participant observation, case study and designing elements.

The Delphi methods has been applied in a way that the author was guided by his practical and research experience. For 40 years he has measured and documented physical effort during judo trainings, military trainings, health-related trainings and while teaching the students of physiotherapy, physical education and recreation. The results have been presented in academic publications, during numerous seminars, conferences, academic lectures and classes. The author of this paper has also been the co-author of workload measurement methods for the purpose of judo [28,29] and physiotherapy [30]. Moreover, the issues of exercise biochemistry and physiology are being consulted with the professors of this specialties having outstanding scientific and practical achievements.

In 2008–2012 the author has performed the analysis of over 3000 research reports which had been conducted by the students of physiotherapy and recreation (n=855) during model health-related training including those based on the exercises of safe falling and avoiding collisions (participant observation). Simultaneously, the previous versions of the method presented in this paper has been modified.

The case study is based on the analysis of documented direct physiological, motor and mental effects in two young females (purposive sampling), who have participated in health-related training based on the exercises of safe falling, avoiding collisions and self-defence. This arrangement of exercises determines the need to measure HR using palpatory methods.

The measurement and documentation method of training load as well as the method for programming the optimal efforts for a given person were based on the components of designing method [31]. The full version of training load measurement and documentation method is applicable only to continuous effort with variable intensity (Table 1). The specificity of the issue is reflected in the structure of the paper which fulfils the editorial standards of the original article and therefore the designing methods are discussed in all parts of the paper. In the *Introduction* some space has been given to the main information enabling '(a) reconstruction of the practical situation [31]', whereas the *Results* and *Discussion and recommendations* provide some complementary statements. The *Results* discusses the subsequent part of the designing procedure i.e. '(b) the formulation of the method to overcome this situation [31]'. In other words, it provides the description of methodology (objectives, methods and methodologies) of measurement, documentation and programming of optimal continuous efforts with variable intensity for a given person in a given day and circumstances (e.g. the place where the activity is performed). The final part of designing procedure i.e. '(c) the verification of the hypothesis' is discussed in the *Results* and *Discussion and recommendations*.

Results

The method for workload measurement of a body after a continuous effort with variable intensity is based on the assumption that the only tool used in measurement process is a stopwatch (or a stopwatch and timer with a second hand) and the results are noted in a special protocol (Table 1). The method is applicable in almost every conditions, especially while registering HR with the use of sport-testers is impossible (during the safe falling exercises involving frequent direct contact as in judo, wrestling, etc.).

The following basic indicators have been measured and noted: the duration of particular measures i.e. given exercises or sets of exercises (T_E), the duration of entire training (T), the intensity of the exercises (I_E), the intensity of the entire training (I).

The duration of the exercises (set of exercises) is measured in minutes. The result should be rounded to the nearest minute (e.g. 5 minutes and 30 or less seconds should be noted as 5-minute effort, while 5 minutes and 31 or more seconds as 6-minute effort). It may be the source of some discrepancies in the duration of entire training being the difference between T_2 and T_1 in comparison with the sum of particular exercises. If a given exercise lasts 20 seconds and afterwards 30-second rest occurs and the entire set is repeated for many times, the 'activity-rest' structure of the exercises and their real performance should be described in '*Content of exercises*' and '*Scope of exercise*'.

The average heart rate recorded accurately to two decimal places is the indicator of intensity (I_E), calculated after the end of a training. The heart rate should be measured using palpatory method each time during 6 seconds several times during the exercise (at 2 or 3-minute intervals) and recorded in 'HR' column in appropriate line. Patient (client) should be instructed that in case of self-measurement of heart rate using palpatory method, if start and end signals are given by other person, the count should start with 'zero'. If there is a possibility for direct observation of the movement of the second hand, the count should start from 'one'. It may be helpful to mark 6-second intervals on the dial (preferably of a big clock) using different colours. This will increase the probability that given person will be able to perform HR measurement during 6–10 seconds after the end of exercise in accordance with recommendations in [21].

Table 1. Sample documentation of physical effort.

Protocol Continuous Workload with Variable Intensity

person *Olivia* gender: M (F) age [year] *23* data of training: *09·11·2011* place: *AWF Katowice*

HR rest *62* HRmax = 208 – (0.7 × age)* *192* HR safety HRR *130*

body mass [kg]: *before- 55,7 after training 55,2 difference 0,5*

T_1 time of start: *16^{00}* T_2 time of end: *16^{50}* T training time [minutes]: *50*

Number of exercises	Content of exercises [description in words, symbols, time structure in seconds etc.]	Scope of exercise [N repetitions of exercises, errors...]	Time [minutes] T_E	HR [during a 6 seconds]	Intensity [average HR] I_E	Exercise load [conventional units] L_E ($T_E \times I_E$)	Intensity zone** [%HRmax]
1	"matador", „act like a snake"		10	12, 13, 15, 12, 14	13,2	132	I_{MO}
2	„playing tag by names", situational falls, „limping fox"	3 negative fair play	14	12, 14, 13, 13, 16, 15, 17	14,28	200	I_H
3	test for safe falls (20load-30rest [s])	6 +:1;2;3';2;4';2 (4 errors')	5	16, 16, 18, 18, 20, 19	17,83	89	I_{VH}
4	recreational forms of combat, self-defence		15	13, 12, 11, 12, 13,15, 15, 16	13,37	201	I_H
5	"matador"		5	13, 12, 13	12,66	63	I_{MO}
			$\Sigma T_E = 49$				

Restitution											
Restitution	minute	1	2	3				ER	HR rest : I	62 : 139	0.446	89
	HR	9	8	7				[%]	HR 3 min after training : I	70 : 139	0.503	

Motivation to exercise		1	2	3	4	5	6	7	8	9	10
Motivation to exercise	before training	1	2	3	4	5	~~6~~	7	8	9	10
	during training	1	2	3	4	5	6	7	~~8~~	9	10

LE	=	L_E + FRT·10
695	685	10

I	LE	695	13,90
	T	50	

I_E	L_E	685	13,97
	T_E	49	

$$L_E = \Sigma(T_{E1} \cdot I_{E1}) + \Sigma(T_{E2} \cdot I_{E2}) + ... + (T_{En} \cdot I_{En}) = \sum_{k=1}^{n} T_{Ek} \cdot I_{Ek}$$

L_E /exercise load/ **LE** /training load/
I /training intensity/ I_E /exercise intensity/
T_E /exercise time/ **FRT** /functional resting time $T - \Sigma T_{Ek}$/
ER /effectiveness of restitution (HR rest : **I**) : ($HR_{3 min\ after\ training}$: **I**)/

classification of effort intensity of adults (%HRmax):

I_{VL} *very light* (<35) I_L *light* (35-54) I_{MO} *moderate* (55-69)
I_H *hard* (70-89) I_{VH} *very hard* (≥90) I_M *maximal* (100)**
I_{SM} *supramaximal* (>100)

*Tanaka et al. (2001) *Age predicted...Journal of the American College of Cardiology; 37: 153-156;*
**Pollock et al (1998) *The recommended quantity... Medicine & Science in Sports & Exercise; 30: 975-991*

The product of the duration of exercise and its intensity (e.g. $T_{E1} \times I_{E1}$) is a measure of the workload after a given exercise or set of exercises (L_E – exercise load). The product of multiplication should be rounded according to the principle that the number after decimal point ≥5, i.e. one should adopt the value of an indicator to be higher by one conventional unit that the number preceding the decimal point. The number ≤4 obligates to round the indicator to the number preceding the decimal point (if the indicator is multi-digit, the last one should be rounded.

Conventional units are therefore a measure of workload after a physical effort (a given exercise and the sum of all exercises performed during a given training). The workload (training load) during the entire training is calculated using the formula $LE = L_E + FRT \cdot 10$, where:

$$L_E = \Sigma(T_{E1} \cdot I_{E1}) + \Sigma(T_{E2} \cdot I_{E2}) + \ldots + (T_{En} \cdot I_{En}) = \sum_{k=1}^{n} T_{Ek} \cdot I_{Ek}$$

and FRT refers to the duration of functional rest ($T - \Sigma T_E$) due to the fact that there are cases when the interval between particular exercises (even though the principles of continuous effort with variable intensity are not violated) will exceed previously set minute or will result from unintentional event (e.g. a need to use a toilet). 10 is an arbitrarily adopted indicator of intensity for functional rest of adults. Because the duration of particular exercises is rounded, the situation when T_E would exceed T is possible (almost always it is one minute). If so, a correction should be made i.e. the duration of the longest exercise or set of exercises (or two sets, T_E is higher than T by two minutes) should be reduced by one minute.

The workload of a continuous effort with variable intensity (the entire training session or other physical labour) is calculated using the formula $I = \frac{LE}{T}$, whereas the intensity of exercises (I_E) is calculated only if functional rest (FRT) has to be determined. In such case L_E (ΣL_{Ek}) should be used instead of LE in the numerator of the formula and T_E (ΣT_{Ek}) instead of T in the denominator of the formula. Both formulas are included in the protocol (Table 1).

Immediately after the end of training (or other physical labour documented with the use of this method), restitution HR should be measured three times during 3 minutes i.e. every 60 seconds – each time by six seconds (it should be recorded in *'Restitution'* line in the protocol – Table 1). Simple restitution efficiency rate (ER; expressed in%) is calculated on the basis of 'triple proportion' formula:

$$ER = \frac{HRrest}{I} : \frac{HR\ 3min\ after\ training}{I}$$

We will receive the identical value of the ER dividing HRrest by HR3 min after training. However the meaning of using fragmentary rates of this formula applies to in-depth analysis. Particular importance is acquiring by $\frac{HR\ 3min\ after\ training}{I}$ especially when we will compare the effects of restitution after trainings, when the difference of intensity (I) does not exceed 3%. The following levels of analysis, the similarity may also concern session time (T), *content and scope of exercise*s.

The protocol comprises moreover the *content of exercises* described in words or symbols and the *scope of exercise* recorded as e.g. the number of repetitions, mistakes or any other relevant information. It also contains a list of symbols used and the classification of workload intensity in adults according to Pollock et al. [15] extended by the supramaximal efforts zone. Each zone was assigned one colour what simplifies the analysis of workload indicators after given exercises calculated after the training (the last column in the report) and the entire training (green part in Table 1 referred to as the *hard* zone).

The measurement of heart rate for 1 minute should be performed only before starting the exercises (basal heart rate). It provides the basis for calculation of *heart rate reserve* (HRR) using the formula developed by Karvonen [32] before a particular training (effort) and forming an association between this indicator and HRmax calculated using the formula of Tanaka et al. [33]. These are the steps required prior to the procedure of optimizing the workload during this particular training session (explanation is provided below in *programming the optimal effort*).

If it is possible to measure body weight before and after the training, calculated difference will additionally provide information about energy expenditure of training load.

Before training a patient (client) should show or circle a number from 1 to 10 in the line entitled *motivation to exercise – before training* (assuming that several people participate in the training session). The number reflects his willingness to undertake the effort (1 – poor motivation, 10 – the strongest motivation). The procedure should be repeated immediately after exercises and the result should be recorded in the line entitled *during training*.

Case study

Three main effects of health-related training were subjects to the observation. They are associated with **exercise physiology** (response of the body to specific exercise with high functional value), **motor skills** (correct control of the body during fall and collision with the ground during extremely intense exercise)

Table 2. Physiological effects of health-related training in two 23 years old females.

Variable	Indicator	Olivia	Kate	Variable	Indicator	Olivia	Kate
Body mass: – before	kg	55.7	60	**T** training time	Minutes	50	50
– after training		55.2	59.2	T_E exercise time		49	48
– difference		0.5	0.8	**FRT** functional resting time		1	2
HRrest	bpm	62	95	**I** training intensity	bpm	139	162
HRmax		192	192	I_E exercise intensity		140	165
HRR		130	97	**LE** training load	Conventional units	695	810
HR after training: 1 minute		90	140	L_E exercise load		685	790
2 minute		80	130	Intensity zone	Symbol & %HRmax	I_H (72%)	I_H (84%)
3 minute		70	130	The proportion of exercise intensity zones [%]	I_{SM}	0.67	2
					I_M	–	6
					I_{VH}	10	28
					I_H	58	60
					I_{MO}	30	–
Effectiveness of restitution	%	89	73		I_L	–	–

Table 3. Motor effects of health-related training in two 23 years old females.

Variable	Indicator	Olivia	Kate
Total number of "test for safe falls" (plan 6)	Count	6	5
Total number of falls during the "test for safe falls" (7 in test during 20 second)		42 + 14	35
Total number of mistakes (15 or 0 points)		4	–

and **mental sphere** (respecting the fair play rules, when competing people accept some forms of physical pressure directed at the competitor and vice versa). Health-related training has constituted an obligatory part of the education of physiotherapy students, however the participation in training has always been voluntary. Out of six volunteers of trainings (deliberately random selection) only Olivia and Kate had similar age (both 23 years old) and high degree of similarity of other characteristics i.e. body weight, motivation to exercise before the training, past motoric experience. Before observed training session they differed in HRR determined immediately before the exercises. In comparison to Olivia, HRR of Kate was 25% lower (Table 2). The results of Olivia have been set to be the frame of reference for further comparative studies (in the opposite direction HRR of Olivia exceeds HRR of Kate by 34%).

Kate performed the same exercises but had higher energy expenditure: 60% higher weight loss, 16.5% higher training intensity, 18% higher exercise intensity, 12% higher HRmax in the same intensity zone. If both young females have performed the same set of exercises during 50 minutes, then higher energy expenditure of Kate would be reflected by the LE indicator (training load), being 16.5% higher than the LE of Olivia and 15.3% higher from L_E (Table 2).

Higher degree of Olivia's adaptation to physical effort is moreover reflected by more efficient restitution. After the first minute of rest Olivia's HR exceeded her HRrest by 61%, after the second minute by 29% and after the third one by 13%, whereas Kate's HR by 47%, 37% and 26% respectively. During 3-minute rest Olivia's heard rate was reduced (regarding I indicator) by 48%, while Kate's only by 21%. Olivia's restitution efficiency rate is 16% higher than Kate's.

Olivia performed exercises with intensity classified to moderate zone for 18 minutes (30% of total duration), for 6 minutes she exercised with very hard intensity and

Table 4. Mental effects of health-related training in two 23 years old females.

Variable		Indicator	Olivia	Kate
Motivation to exercise:	– before training	Points [1–10 scale]	6	6
	– after training		8	6
Breaking the rules of fair play („playing tag – by name", „limping fox")		Count	3	–

for 20 seconds with supramaximal intensity (Table 2). The same programme of training session, in terms of its content but not the number of repetitions planned to stimulate the highest intensity possible, caused Kate's effort to be more intensive. Altogether 8% of exercises (ca. 5 minutes) were considered as maximal and supramaximal.

During 5 minutes Olivia six times performed the 'test for safe falls' (see Table 1, exercise 3), whereas Kate performed it just five times. Moreover, Kate was able to perform only 7 falls during each 20 seconds of the test, i.e. 35 in total in 5 sets. Olivia performed from 1 to 4 falls more during each 20 seconds i.e. 56 in total (Table 3). Only once she was able to perform 11 falls during 20 seconds what was reflected by exercise intensity being at supramaximal zone. During this set of exercises Kate's HR indicated supramaximal effort three times after 20-second test (therefore, she did not perform the sixth set of exercises).

Olivia performed 'test for safe falls' so fast that she committed 4 mistakes (Table 3). In the protocol (*Scope of exercise* column: apostrophe next to numbers 3 and 4) it is noted that the mistakes were committed during tenth and eleventh fall (Table 1). The mistake was defined in a very rigorous manner: 15 points in 25-, 20-, 15-, 0 points scale ('**15** *points for execution of the task in an insufficiently dynamic way and with mistakes, which nevertheless do not affect a change in the type of movement'* [34, p.85]).

During the training session it was Olivia who has increased her motivation to exercise (Table 4). The effects on mental sphere have been estimated with respect to fair play rules and have been higher in Kate. Olivia has broken three times the rules of kimono belt during recreational forms of combat (*playing tag – by name* and *limping fox* [35]).

Programming the optimal effort

Quasi theoretical indicator of maximal *safety training load* (STLmax) has been the basis for calculation of one of several variants of optimal training load for a given person in a given day. It is a product of 60-minute effort and HRmax calculated using the formula of Tanaka et al. i.e. 208 – (0.7 × age) [33].

$$STL_{max} = 60 \times (HR_{max} \times 0.1)$$

Assuming that the training session should last for 60 minutes, the optimal training load (TL*optimal*) is determined by the *heart rate reserve* (HRR) calculated using the formula of Karvonen [32]: HRR = HRmax – HRrest.

$$TL_{optimal} = 60 \times (HRR \times 0.1)$$

Coefficient 0.1 in both formulas causes that *conventional units* (cu) are reduced tenfold facilitating mathematical operations, especially adjusting this indicator to **LE** indicator (training load) and $\mathbf{L_E}$ (exercise load).

STL*max* equals **1152** cu for Olivia and Kate. If the training lasted for 60 minutes that day (!), TL*optimal* for Olivia would amount to **780** cu and **582** cu for Kate. Yet, during 50-minute training session Olivia performed 89% of TL*optimal* and 60% of STL*max* with the training load amounting to **695** cu. Kate performed respectively 139% (i.e. the supramaximal training load) and 70% with the training load amounting to **810** cu.

If the training session of both females was not limited by time, with the target training load amounting to **1152** cu the optimal *training duration* should be calculated using the formula:

$$TD_{optimal} = STL_{max}: (HRR \times 0.1)$$

Olivia should exercise for 89 minutes, while Kate for 119 minutes. It means that Olivia should maintain the intensity of the effort between moderate and hard zones (according to Pollock et al. [15]) to perform approximately 90-minute safe training session in accordance to the STL*max* criteria. Kate, on the other hand, should exercise for approximately 120 minutes between light and moderate zones.

In fact, during 50-minute training session Olivia's heart performed ca. 6 950 beats, whereas Kate's ca. 8 100 beats (Table 2). If this exercise intensity was maintained, Olivia would reach **1152** cu (i.e. 11 520 heart beats) after 83 minutes, while Kate 12 minutes earlier. These numbers reveal the risk if Kate, stimulated internally (by herself) or externally, sought to achieve such goal.

Discussion and Recommendation

Adoption of quasi theoretical STL*max* indicator has strong theoretical support and is grounded in the practice of training. Most cardiologists, specialists in sports medicine, physiologists and experts in physical training recommend 60 minutes as the time limit of one session of health-related training [5,6,19,36,37]. Vivian Heyward [6] points out even 70-minute of typical water-based exercise session and lists four phases: warm-up (20 min.), endurance phase (30 min.), resistance chase (10 min), cool-down (10 min).

Sixty-minute limit together with HR*max* constitute the degree of effort safety. Coefficients, by which the age is multiplied, used so far in the formulas reflect recommended safe limits of the effort intensity, e.g. 0.8 [14] 0.7 [33], 0.65 [4], and in case of patients with ischaemic heart disease they amount to 0.63 or even to 0.41 [38]. This differentiation is relatively smaller in the determination of final heat rate. Leaving apart the simplest formula i.e. 220 – age, the variability of this indicator does not exceed 9%: 214 [14], 210 [4], 209 [14], 208 [33], 205, 199, 198 [38].

Therefore, trained people are able to perform even several training sessions during a mesocycle lasting many weeks in accordance with STL*max*. Being 62 years old, the author had personally fought 5 randori judo separated by 5 to 7-minute rests during 60-minute training session (his rival was 38 years younger). Each randori was a supramaximal intensity for the author. Immediately after the fights HR amounted to 180-, 180-, 190-, 190-, 200 bpm. HR*max* amounting to 165 means exceeding this theoretically safe limit twice by 9%, twice by 15% and once by 21%. The total workload during 60-minute training session (LE) amounted to **941** cu: 10-minute warm-up (**120** cu), 25-minute randori (**470** cu), 25-minute rest before randori (**351** cu). Since the STL*max* for a person aged 62 equals **990** cu, the author had made the effort accounting for 95% of this standard during the training session.

From the medical perspective the above mentioned example is only seemingly not worthy to follow. In the laboratory Santos et al. [39] noted in national level judokas HR*max* accounting for 200±4.0 bpm, whereas during the specific field test (Santos) it amounted to 201.3±4.1. Apparently, the author who practiced judo for 50 years maintained this specific adaptation. The specificity of randori judo, i.e. a fight one against one, makes one-time effort to be continuous with variable intensity. However, a few second rests do not significantly influence the metabolism (reflected by a significant decrease of HR). Motor activities are directed at the rival and vice versa, hence quoted physiological effect is understandable with so high fight dynamics. During multiplayer games (the specificity of rivalry in soccer is different from judo) the effort intensity decreases together with larger number of players [40]. It seems obvious that the more players, the less one against one fights for ball and less opportunity to intensify efforts in this way.

While practicing randori judo, the author has experienced motor, praxeological (the effectiveness of fights) and mental effects, which are worth recommending. Experiencing of the capabilities, deriving satisfaction and motivation from this form of training were enabled by the video recording of the training session. This issue is emphasized here because physiological aspect of the effort is highlighter in numerous publications concerning health promotion. This results in opinions that favours cyclic efforts, mainly walking, running, cycling, etc. Yet, more sophisticated measures are needed for the improvement of mental and social health as well as maintaining the optimal ability to survive [17,18]. These issues are discussed extremely rarely. Judo practised throughout the entire life in accordance with the concept developed by Jigoro Kano [41] fulfils this criterion. Exercised with caution, judo combined with other forms of physical activity may produce the expected physiological results, which are equated with the somatic health. As the offer of various forms of exercises is increasing, the individual choice is determined by numerous factors. People make choices basing mainly on emotions and underestimating their genetic predispositions and previous motor experience what may turn up as serious threat for health and life.

The limits of adaptation are very broad. The Ethiopian Kenenisa Bekele did not participated in 12-minute Cooper test. However, during 5 kilometre run, when he set the world record, after 12 minutes he was on 4730 meter. It means that he was running with average speed amounting for 24 kilometres per hour. The result of Tirunesh Dibaba, his compatriot, is 4110 metres. Polish professional runners cover a distance of over 4000 metres during the Cooper test, while females ca. 3500 metres. Marathon record holder Patrick Musyoki Macau, while establishing it, ran ca. 4 100 metres every 12 minutes.

This data and the examples of Olivia, Kate and the author indicate on the one hand limited possibilities to accurately interpret training load (LE indicator) even if the analysis is based on determining reliable relationship between the duration of the effort (T and T_E) and intensity (I and I_E). On the other hand, they show that a comprehensive diagnosis should be based on as careful analysis as possible of the *content of exercises* and the *scope of exercises*. It is only the accurate analysis and as a consequence training load programming that increase the likelihood of optimal personalization of particular training sessions and progressive increase of the workload in the subsequent training cycles until the desired effect will be achieved. As far as stabilization of the training load is concerned, cyclic efforts classified as STL*max* formula will gain significant importance, even though it is impossible to stop involutional processes. Everyone who has been training for many years will come sooner or after to the conclusion that understating of the training load and exceeding the workload (safe and at the same time fitness shaping or maintaining) may be equally unfavourable for a given person. Underestimating and exceeding the safe workload usually occurs when there is lack of reliable information about the condition of the patient (client).

It seems that underestimation of the recommendation to document the *content of exercise* and *scope of exercise* as precisely as possible makes it impossible to determine detailed causes of particular adaptative changes. The training load of young females (n=6), who participated in 10-week long health-related training based on safe falling exercises and avoiding collisions [42], documented with this method, correlates quite highly (r=0.760 at directional *vs.* $p<0.05$) with the results of rotation test, which measures body balance disturbation tolerance skills. Females, who have performed larger effort (higher total value of LE indicator) in this mesocycle, committed less mistakes during rotation test after this training stage. Three issues are certain: (1) each training session and as a consequence total duration of each session was identical for every person; (2) personal differences of a total training load (LE) result from different exercise intensity (19% variability); (3) higher exercise intensity (with the similarity to HRR) arise from a larger number of repetitions of given exercises at the same time.

Only those, who have limited the number of mistakes during rotation test, have exercised with intensity categorized as maximal and supramaximal (they constituted from 3% to 13% of LE). Unfortunately, the most important issue still remains unknown. It is due to the unreliability of the documentation mainly of the number of repetitions of rotation exercises in a given period of time, why there are no grounds to note what is a direct reason of these positive adaptative changes. What remains is to construct the explanatory hypothesis that the higher number of exercise repetitions cumulates proportionally rotation exercises performed more often (in this programme), stimulating the body balance disturbation tolerance skills which can be proved by the test applied. This example is used to show how important and difficult is to create awareness of future experts in health-related training. It must become a serious challenge to re-develop the awareness of potential patients (client).

The criticism of the method may include the palpative method of HR measurement. It has already been highlighted that this is the best manner in some exercises. A patient (client), who is professionally prepared to practice health-related training on his own, should be sure that he is able to perform the HR measurement in all circumstances if he has a reliable timer.

The reliability of HR measurement using palpative method may be proven by a simple experiment. It is enough to perform several measurements controlled by a leader during the training session. A patient (client) equipped with a sport tester measures HR on the carotid artery using the palpatory method in the time set by the leader, and does not confront the results with the sport tester but records the results in the worksheet. Directly after the signal indicating the end of measurement, the leader checks the result on the sport tester and records it on his worksheet. The number of measurements is voluntary, but at least half of them should be performed for 6 seconds, while the other for 10 and 15 seconds. If the difference between measurements made with palpatory methods and the readings of a sport tester for 1 minute does not exceed 10 BPM, it may be assumed that a patient (client) has mastered this activity (Table 5). Hence, acceptable error during HR measurement performed using palpatory method by a patient (client) during 6 seconds and simultaneously by a leader amounts to 1 beat (10 bpm if calculated per minute).

HR measurement with a sport tester is a proven method during numerous regular forms of physical activity or games. GPS opens new possibilities [44,45]. Breaks to measure HR are no longer necessary. Nevertheless, the usefulness of indicators for workload monitoring for the purposes of rehabilitation, health-related training, especially of the elderly, sport for all, etc. instead of the way of HR measurement constitute more serious issue. Aerobics points system, MET and other indicators are invaluable. Published compilations of various forms of recreational and sports activity refer to them and facilitate the calculation of weekly planned or executed energetic cost. Assuming the reasonable increase of the workload it is hard to programming and modify further training sessions basing on those general indicators (e.g. 7 MET for skiing, 3 MET for bowling [5]).

There is a high awareness of two phenomena among the specialists [e.g. 6, 13, 33]: (1) in spite of the same age and somatic similarity various people have different reactions for the same exercise programme; (2) the

Table 5. The verification of accuracy of palpatory HR measurement based on the comparison of sport tester indications.

Measuring timing [s]	Palpatory measurement		Sport tester
	Beats	bpm	bpm
6	12	**120**	**124**
6	14	**140**	**143**
10	24	**144**	**150**
6	15	**150**	**161**
15	38	**152**	**155**
10	26	**156**	**159**
6	16	**160**	**157**
15	41	**164**	**171**
Arithmetic mean		**148.25**	**152.5**
Difference		**4.25**	

necessity to personalise the workload has much broader explanation than it would follow from (1).

Progress in optimizing the personalisation of the training load, which is necessitated by the need to use various physical exercises determined by the multiplicity of needs (from rehabilitation to extreme sports), is hindered by lack of terminological consistency, sometimes taken to absurd levels. This issue has been tackled in the *Introduction* (*The field of the training theory, praxeology and systems science*). Some author identify the same indicators with the effort intensity, others attribute them the value of training load measures, etc. Perhaps, this is a main reason for lack of reliable answer for an obvious question of what are the causes of training effects after shorter and longer cycles documented with scientific accuracy. That 'cause' in the most general sense may be defined as the synonym of training load.

It is the easiest to provide examples concerning youth sport. The effects are in fact a consequence of the accumulation of training stimuli and factors stimulating the natural biological development during this stage of ontogenesis. For example, the development of fitness capabilities of young judo athletes such as speed, endurance, strength is well documented [46,47]. There are no empirical data to clearly answer the question about the training load, which determines this conditions. It is easier to infer about the influence of training in comparison with the factors stimulating this natural development of motor skills. There are many scientific researches concerning the biological development of children and adolescents, which are not additionally stimulated by sports training.

Jaskólski et al. [13] have developed the standards of physical preparation of children to various sports disciplines and well-grounded guidelines for personalisation of children' and adolescents' training in terms of physical development. Many guidelines concern planning of the training load value. Slightly different objectives form the basis for personalized exercise programmes suggested by Heyward [6, p. 107–116]. However, in both cases the procedures are finished with determination of training load. This decision is partially based on the same indicators (HR, time, frequency). Both recommendations are linked with another common feature. They constitute an example of methods with as high measurement accuracy as possible (and ultimately planning and programming the training loads) in contrast to very general and hence unreliable methods based on a single indicator (MET, Aerobics point system, etc.). This positive assessment, however, does not exempt from the allegation that making comparisons of planned or executed training loads requires analysis of numerous indicators and determination of criteria authorizing the conclusions with consistent factual value, especially when two different methods are used. Paradoxically, this comparative study indicates that solving the same problem by scientists being experts in various politics systems finally leads to very similar generalisations. Perhaps, one of the major obstacles hindering the progress in numerous applied sciences is a limited access to papers published in languages of the countries from outside the Iron Curtain [see 49].

The advantage of the methodology of measurement, documentation and programming of the workload presented in this paper is the possibility of expressing this variable using the universal **LE** indicator, which is based on conventional units. It may be used at every level of preliminary analysis i.e. from particular exercises and set of exercises (L_{E1}…, etc.), through particular training

Table 6. Preliminary programming of optimal training load according to patient's (client's) age with established HRrest accounting for 60 bpm and recommendation for those who declare daily physical activity to shorten the duration of training session i.e. TLoptimal (calculated for 60 minutes) assuming the exercise intensity being 80% HRmax (the middle of *hard zone*).

Age [years]	HRmax [bpm]	STLmax [uc]	HRR [bpm]	TDoptimal [min]	TLoptimal [uc]	% STLmax		Recommendations for 80%HRmax	
								Intensity (HR)	Time*
						[%]	Intensity zone	[bpm]	[min]
20	194	**1,164**	134	87	**804**	69		155	52
30	187	**1,120**	127	88	**762**	68		150	51
40	180	**1,080**	120	90	**720**	67	Moderate	144	50
50	173	**1,038**	113	92	**678**	65		138	49
60	166	**996**	106	94	**636**	64		133	48
70	159	**954**	99	96	**594**	62		127	47

* Time = TLoptimal: (0.8 × HRmax) × 0.1.

Table 7. Preliminary programming of optimal training load according to patient's (client's) age with established HRrest accounting for 90 bpm and recommendation to shorten the duration of training session i.e. TLoptimal (calculated for 60 minutes) assuming the exercise intensity being 70% HRmax (contact point of *moderate* and *hard zones*).

Age [years]	HRmax [bpm]	STLmax [uc]	HRR [bpm]	TDoptimal [min]	TLoptimal [uc]	%TLoptimal		Recommendations for 70%HRmax	
								Intensity (HR)	Time*
						[%]	Intensity zone	[bpm]	[min]
20	194	**1,164**	104	87	**624**	54		136	46
30	187	**1,120**	97	88	**582**	52		131	45
40	180	**1,080**	90	90	**540**	50	Light	126	43
50	173	**1,038**	83	92	**498**	48		121	41
60	166	**996**	76	94	**456**	46		116	39
70	159	**954**	69	96	**414**	44		111	37

* Time = TLoptimal: (0.7 × HRmax) × 0.1.

sessions (L_{E1}..., etc.) to microcycles, mezocycles, macrocycles and long-term cycles (L_{week1}..., etc.; $LE_{months1}$..., etc.; $LE_{year2012}$..., etc.; $LE_{years2012–2015}$..., etc.). The next step of analysis is to decide whether the LE value is the effect: of either the relative balance (in terms of health recommendation, individual diagnosis involving safety effort, etc.) time and the intensity of an exercise (exercise); or extending the duration of the exercise with given reduction of intensity or vice versa; or compilation or various 'activity-rest' systems. Quantity and quality evaluation play more significant role on the next step of the in-depth analysis. For example, the following questions must be answered: whether the exercise intensity is determined by patient's (client's) commitment and whether it is connected with the motivation to exercise declared or estimated by the leader (trainer, physiotherapist, etc.) or with the skill performance or incentives of the leader; whether the same exercise intensity threshold is a derivative from the same number of repetitions. Te number of objectively relevant questions, which can be asked by the leader of health-related training, depends on his skills and sense of responsibility.

Following the algorithm, presented in detail in this paper, in accordance with the methodology does not deny the use of recommended quantitative and qualitative indicators. Quite the opposite, the more precisely is the training load documented, the more reliable premises that the personalisation has been accurate and achieving the health goals is more likely. If a person wants to meet specific sport targets, careful documentation of the training load would be helpful in personalisation of the next training sessions and may protect against the effects of reckless overloads.

The need for training load documentation during current training session forms the basis of workload optimisation during subsequent training sessions, especially in rehabilitation of cardiac and type-2 diabetes patients, geriatrics, sport for all of people over 40. Moreover, the self-assessment of the physical effort tolerance may turn out to be very helpful in progressive increase of the next efforts or its reasonable reduction. This may be based on the scale of workload perception developed by Borg [49] or on 10-point scale similar to motivation to exercise scale. Calculations in Tables 6 and 7 are only the clue on how to create a measure (suitable for a person in a given age) which would facilitate the decision making process about training load during the current session. HRR and the knowledge of effort tolerance during previous training sessions, preferably with the same or similar content, constitute the basis for determination of the training load.

Conclusions

The 60-minute effort limit adopted in this methodology is only the quasi theoretical indicator. There are people at retirement age, which spend many hours skiing, hiking or doing other long efforts. Personal profile of optimal training load for weekly or longer cycles can be determined basing on the methodology presented in this paper. It may serve as a tool to specify the daily safe workload and its implementation. The health effects of these specific records should be verified by the expert in sport medicine. Controlled physical effort is in fact a significant part of the 'polyhedron of a worthy life' i.e. rational decision making, respecting the chief values, optimal physical activity, healthy nutrition and habits, friendly work environment and leisure.

The author would like to highlight that the interdisciplinary issue tackled in this paper exemplifies the need to formulate the new paradigm. The present one can be defined as common belief (consolidated by dozens of academic publications and implementation of the procedures) that physical effort should ensure the proper functioning of the human body in a physiological sense. Physical effort is an essential part of self-development in many fields including art. Physical effort with the specific content is the source of satisfaction and a standard of quality of life, which cannot be provided by universally recognized intellectual achievements. The reduction of health promotion and physical activity mainly to walking, running, cycling or other simple forms of exercise may *counterproductive* in the longer term. That is, instead of achieving the ultimate goal of common physical activity we will achieve its negation.

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