Journal of Physical Education and Sport ® (JPES), Vol. 24 (issue 8), Art 204, pp. 1840 - 1848, August 2024
online ISSN: 2247 - 806X; p-ISSN: 2247 – 8051; ISSN - L = 2247 - 8051 © JPES

Original Article

Assessment of exercise intensity using the Phyphox Mobile App

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Published online: August 31, 2024
Accepted for publication : August 15, 2024
DOI:10.7752/jpes.2024.08204

Abstract:
This study aimed to explore the use of a specific high-intensity interval training (HIIT) program, assess exercise using with the Phyphox mobile application, and evaluate the reliability of this measurement technique. In a single-participant case study, we designed a short burpee movement program (BMP) comprising 3 sessions of 3 minutes each, with a one-minute break, in between. Participants performed burpees at regular intervals upon hearing a sound signal. Three variants of the BMP were developed: based on the number of repetitions: B7 (26 repetitions per round, 78 repetitions per BMP), B6 (30/ repetitions per round, 90 repetitions) per BMP), and B5 (35/ repetitions per round, 105 repetitions per BMP). Each variant was performed 3 times with varying intensity (Bs – burpee performed slowly, Bf – burpee performed quickly, Bme – burpee performed with maximum effort). A total of 9 training units were completed in our research. The acceleration values, heart rate and jump height during the burpee were recorded. Subsequently, the round intensity, burpee intensity and fatigue index were determined. The slowly performed burpee ranged from 3.5 to 3.8 ms-2, the quickly performed burpee ranged from 9.2 to 10.6 ms-2, and the maximum effort burpee 10.9 to 12.9 ms-2. The fatigue index was slightly noticeable during the less intense variant, but maximum effort reached 25% in B5. Depending on the intensity, the heart rate ranged from 120 to 168 bpm and the jump height varied from 2 to 11.9 cm. A significant correlation was found between round intensity, burpee intensity, heart rate and jump height. When set to measure the acceleration values, the Phyphox mobile application can reliably assess exercise intensity.
Key Words*:* **burpee, assessment, exercise intensity, mobile application, index of fatigue**

Introduction

Physical activity is becoming an integral part of a healthy lifestyle. High-intensity interval training (HIIT) has recently become one of the emergent training methods and is gaining in popularity mainly because of its effectiveness and safety even for individuals with different levels of fitness (Gibala, 2008). Although HIIT does not have a universal definition, it involves repeated phases of short, intermittent exercise, usually performed at a high intensity, and it is interspersed with active or passive recovery periods (Buchheit, 2013). Depending on the target group and focus, these trainings can have different uses. HIIT can be adapted to prevent health problems, but it can also be aimed at improving the daily activities and reducing the risk of falls in older adults (Silva, 2023; Nytrøen, 2022; Marriot, 2021). For the general population, the biggest benefits are in reducing body fat, improving cardiovascular health and increasing muscle strength (Liu, 2022; González-Gálvez, 2024). However, the effectiveness of HIIT protocols has also been demonstrated in the field of aerobic and anaerobic endurance (Milioni, 2024; Bossmann, 2023), and also in the field of performance sports (Wu, 2023; Ní Chéilleachair, 2017). HIIT exercise programs allow us to use several variables, such as intensity and length of exercise and the rest interval, number of repetitions and number of sets, and can be performed using many types of equipment and exercises, such as bicycles, treadmills, running, free weights, sailor ropes – and even exercises that make use of one's own body weight (Leite, 2023).

Today, one of the most popular bodyweight exercises is the "burpee" (or the English squat), designed by R.N. Burpee in the 1920s. It is well-known globally, with related games and competitions held worldwide (Pelovoy, 2023). This functional exercise combines squats, planks, push-ups and lunges, making it highly effective for burning fat. When performed with proper technique, it engages all major muscle groups, including the chest, back, legs and abdomen. No special or heavy equipment is needed, as it relies solely on body weight (Podstawski, 2013; Tai, 2022). Additionally, the exercise can be performed at varying speeds, affecting the intensity and acceleration. Burpees have been featured in many research studies, often as part of a diagnostic test where the number of repetitions and speed were the key factors (Moura, 2016; Kojic, 2021; Podstawski, 2019). They have also been used to develop movement capacity (Cepulenas, 2011; Masagca, 2024) and assess the physiological responses during HIIT programs (Perez-Ifran, 2022; Bingley, 2019; Mayr Ojeda, 2022). However, we found no existing research evaluating the individual repetitions in terms of their course and intensity. Our

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research has been focusing on this exercise for quite some time. In the past, we devoted ourselves to the use of the Burpee in fitness training (Šiška, 2017; Šiška, 2020), in which the exercise programs had a 3x3 minute structure with a one-minute break, which exactly simulates the duration of a boxing match. This format was chosen primarily for its time efficiency. In the first case, the Burpee was modified and the end jump was eliminated and replaced by a lunge with a blow to the measuring plate. The English squat was performed one by one at a visual signal and at regular intervals, with an emphasis on maximum performance. In the second case, we used a movement sequence that consisted of a push-up, movement around the dummy and another Push-up. The test subject performed this sequence according to his subjective feelings. The movement programs were designed as high-intensity interval training (HIIT), but due to the difficulty of their execution and the need for additional measuring devices, they were not easy to implement. If we want the movement program to be accessible to the general public, it must be simple and easy to use. In this context, doing the classic Burpee without the need for additional equipment, for example at a sound signal, is the most reasonable solution. This way, we can ensure that the exercise is accessible and feasible for as many people as possible regardless of their physical condition or access to special training equipment.

Due to the fact that sports are becoming more and more technologically oriented, there is a growing demand for monitoring the course of physical activity and diagnosing the motor performance. People want to know whether they improve in a given exercise or not (Mali, 2020). In recent years, a number of affordable activity tracking devices have been introduced to the market. Smart bracelets and other similar devices provide statistical parameters and record events of specific physical activity, for example, heart rate, distance, etc. (Grun, 2011). A suitable parameter that can be monitored is acceleration, and according to Pernek (2015), acceleration is a critical factor for achieving excellent results in the context of sports and the ability to change the speed of movement plays a key role in many sports disciplines.

A new approach in monitoring the intensity of exercise is provided by mobile applications that can monitor and evaluate the intensity of exercise on an individual level with the help of integrated sensors, which are also suitable for measuring acceleration, thereby contributing to a more accurate plan of physical activities (Mateo-Orcajada, 2024). In addition to recording the data from such sensors, the PHYPHOX app can process the data from sensors in real time, and in some settings also in advance. Considering the fact that the vast majority of population owns a mobile phone that can record acceleration, we have a readily usable and simple way to monitor and evaluate the course of physical activity (Pierratos, 2020). In our past research, we video-recorded and analyzed the acceleration values obtained through the PHYPHOX mobile app while performing the Burpee. We defined the beginning and end of the exercise, and were able to quickly filter the values corresponding to the individual English squats using the moving average smoothing method from the data exported to MS Excel. By averaging these values, we expressed the intensity of the exercise (Šiška, 2024).

If we consider that we can accurately identify the acceleration during the Burpee using the PHYPHOX mobile app and create a short-interval high-intensity burpee movement program based on this exercise, we will be able to monitor its intensity and – with repeated measurements – also evaluate the reliability of monitoring the movement activity with the help of a mobile phone. This way, we want to contribute to a better understanding of the use of mobile technologies in the field of sports and physical activity, and at the same time provide instructions on how to exercise and reliably monitor and evaluate the intensity of exercise for the general public and performance athletes. The aim of our work follows from the above.

Materials & Methods

Study design

In this study, we wanted to present the possibilities of using a specific HIIT program and verify the reliability of intensity measurement in this type of load using the Phyphox mobile app. We used the method of repeated measurements of the same phenomenon – the Burpee within the Burpee Movement Program under precisely defined controlled conditions. In the course of our research, altogether 9 training units were completed at in identical time periods and under constant conditions. Each training unit was preceded by the same 10-minute warm-up consisting of dynamic stretching, functional multi-joint exercises and a series of 5 English squats. The single test subject participating in this case study was 41 years old, with a height of 172 cm and weight of 72 kg.

The test subject was in a reasonably good physical shape with the following performance characteristics: sit and reach tests - 21 cm (Hoffmann, 2019), sit-ups 30s - 32 repetitions, standing broad jump - 243 cm (Ab Rahman, 2021) and Leger beep test - 1680 m, which corresponds to VO_{2max} - 44.5 ml.kg $^{-1}$.min $^{-1}$, at a maximum heart rate HR max. 175 bpm (Ramsbottom, 1988) and resting heart rate in level 69 bpm (Li, 2014). The total sports age of the test subject is 35 years and he is a multiple Slovak champion in athletics and kickboxing. The test subjects did not suffer from orthopedic and neurological injuries. The procedures presented were in accordance with the ethical standards on human experimentation and in compliance with the Helsinki Declaration. All subjects were informed about the potential risks and signed a written informed consent before data collection.

The Burpee Movement Program (BMP)

The movement program had the same time duration as the boxing match, i.e. 3x3 min., with a minute-long break between the rounds. It consisted of performing the burpees at a sound signal at regular intervals. The course of one sequence (Burpee) consisted of the basic position (standing upright), from which the test subject moved after the sound signal into the lying position with outstretched or slightly bent arms in the shortest possible time, followed by the second phase transition from the lying position into a jump and back to the basic position (standing upright). Depending on the number of repetitions, three variants were proposed. The first variant, i.e. B7, featured a repetition of the sound signal every seven seconds, which represented 26 repetitions in one round and 78 repetitions for the entire load interval. The last signal in the round was issued at 2:56 min. and it was followed by a 1:04 min long break to maintain the time range. In the second variant, i.e. B6, the sound signal was issued every six seconds, which represented 30 repetitions in one round and 90 repetitions for the entire load interval. The last signal in the round was issued at 2:54 min. and it was followed by a 1:06 min. long break to maintain an identical time range in each variant of the movement program. The last variant, i.e. B5, featured a repetition of the sound signal every five seconds, which represented 35 repetitions in one round and 105 repetitions for the entire load interval. The last signal in the round was issued at 2:55 min. and it was followed by a 1:05 min. long break to maintain an identical time range in each variant of the movement program. Each variant was repeated three times with an emphasis on the changing the intensity of load, which was controlled by the subjective feelings of the test subject. The movement program started at the slow Bs pace, followed by the fast Bf pace, and ended by maximum effort Bme (Fig. 1).

Fig. 1 Testing protocol

We used a mobile phone, which can capture the measurement data using its sensors, including the built-in accelerometer, to measure the activity during the short-interval exercise. The acceleration values were collected using the PHYPHOX mobile app with the mobile phone in a case attached to the test subject's left arm just below the deltoid muscle. The PHYPHOX app recorded the accelerations along the x, y and z axis and the total magnitude of acceleration m = $\sqrt{x^2 + y^2 + z^2}$ in ms^{-2} with the relevant time stamps. The values were recorded without the gravity G component and when the mobile device was motionless, the acceleration values had a zero value in all positions. In our research, an iPhone SE with a recording frequency of 100 Hz was used. The measurement data were exported into csv and MS Excel, with the first column containing the time values, followed by the accelerations on the x and y axis and the total m (phyphox.org).

The jump height in centimeters was estimated using a photoelectric cells system (Optogait, Microgate, Bolzano, Italy). The heart rate was recorded using a SUUNTO device that receives wireless signals from a Suunto heart rate monitor. It displays the heart rate of athletes in real time, recording the changes every second and providing information about the performance of each athlete. The SUUNTO team manager device consists of a PC, a Suunto receiver and a chest strap. The results section was populated with average values (AHR) and maximum values (MHR) of the heart rate in the individual rounds.

Statistical analysis

In our research, we worked with the values of total acceleration magnitude (m). The phyphox mobile app recorded around 66000 readings during the load phase. In the first step, we identified the data corresponding to approximately 18,000 individual rounds and calculated their average, which translated into round intensity (AIR). One burpee was represented by approximately 200 to 400 acceleration values depending on the execution speed. When processing the data from the accelerometer, we extracted the values for each English squat separately in MS Excel and determined their average value. When filtering the values representing the English squat, we used the moving average smoothing method. To eliminate the unwanted external factors, an average of 11 values (5 before and 5 after the given value) was used instead of the given value, and the data were smoothed 9 times with this method. The beginning of the exercise was identified by the smoothed acceleration value exceeding the limit of 0.5 ms^{-2} and not falling below this limit for the next 100 values. The end of the exercise was identified in a similar way, but from the opposite side: the acceleration value had to exceed the limit value of 3 ms^{-2} and the next 100 values did not fall below this threshold (Šiška, 2024). We calculated the average from the selected single repetition data, which indicated the intensity of the burpee. This way, we obtained 26, 30 or 35 values for one round and the results section was populated by the average value of the English squat in the individual rounds (AIB). The performance drop (IF) is expressed as a percentage difference of the maximum and minimum values on the linear trend line with regard to the minimum value. The performance decreased and the linear trend line was dropping with a positive value of the fatigue index, and the performance increased during the round and the linear trend line was rising with a negative value of the fatigue index (Šiška, 2017).

The collected data were analyzed using descriptive statistics: mean (M), standard deviation (SD), maximum (max) and minimum (min). The significance of the differences between the compared groups was calculated using a two-factor ANOVA with repetitions. Shapiro-Wilk test was used for multivariate normality check. Spearmon's correlation (rs), the coefficient of determination (R^2) and the 95% confidence interval were used to determine the relationships between the variables. The significance levels were at $p < 0.05$ and $p < 0.01$. The statistical analyses were performed in MS Excel 2016, IBM SPSS 22 and JASP 0.16.4.0.

Results

When evaluating the specific variant B5, which was performed with maximum effort, we can state that the intensity of the Burpee ranged from 10.49 ms $^{-2}$ to 12.90 ms $^{-2}$ with an average intensity of 11.68 ms $^{-2}$ in the first round. Linear performance dropped from 12:51 ms $^{-2}$ to 10.85 ms^{-2}, which represented a fatigue index of 13.31%. In the second round, the intensity of the Burpee ranged from 9.75 ms $^{-2}$ to 12.94 ms $^{-2}$ with an average intensity of 10.93 ms $^{-2}$. Linear performance dropped from 12.47 ms $^{-2}$ to 9.40 ms $^{-2}$, which represented a fatigue index at a level of 24.63%. In the third round, the intensity of the Burpee ranged from 9.05 ms $^{-2}$ to 12.63 ms $^{-2}$ with an average intensity of 10.43 ms $^{-2}$. Linear performance dropped from 10.86 ms $^{-2}$ to 10.00 ms $^{-2}$, which represented a fatigue index at a level of 7.89%. When evaluating the entire course of the test, the average intensity of the English squat in all three rounds was at a level of 11.02±1.06 ms $^{-2}$. Linear performance dropped from 12.16 ms $^{-2}$ to 9.88 ms^{-2}, which represented a fatigue index 18. 77% (Fig. 2).

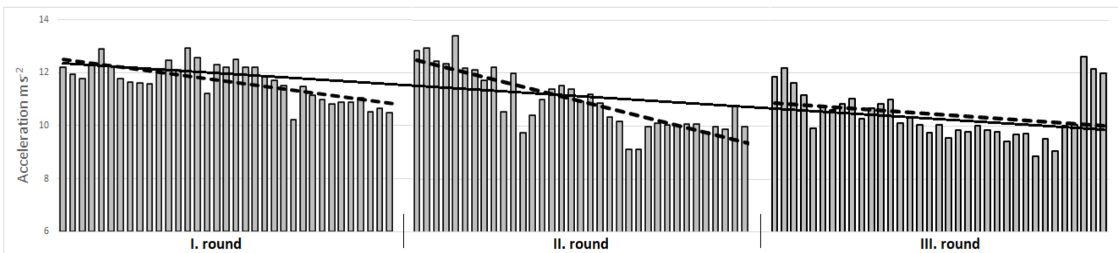

Fig. 2 Course of Burpee movement program

When comparing the results, it was shown that the intensity within the entire round increased with regard to the speed of the Burpee $F(2, 26) = 1574.7$, $p < .01$, and it also grew with the increasing number of repetitions $F(2, 26) = 564.55$, $p < .01$. When performed at a slow pace, the average intensity between the rounds did not change $p > 0.05$ within the individual variants B7, B6, B5. When monitoring the average intensity of the Burpee during the round, it increased significantly with respect to the execution speed $F(2, 26) = 1153.4$, $p < .01$, however, the intensity of the English squats remained the same $F(2, 26) = 2.47$, $p > .05$ with the increasing number of repetitions (Tab. 1).

Tab. 1 Average intensity in round and average intensity of burpee during the research

			AIR		Anova		AIB		Anova
type	round	B7	B6	B5	two factor	B7	B6	B5	two factor
	I	2.40	2.78	3.32		3.75	3.84	3.82	
Bs	II	2.32	2.76	3.29	Bs-Bf-Bme	3.75	3.58	3.65	Bs-Bf-Bme
	III	2.38	2.77	3.31	effect	3.73	3.56	3.67	effect
	I	3.64	4.41	5.22	**	9.39	10.68	10.46	**
Bf	II	3.49	4.28	5.36		9.33	10.24	10.70	
	III	3.50	4.32	5.23	B7-B6-B5	9.23	10.22	10.10	B7-B6-B5
	I	4.33	4.94	5.74	effect	12.97	12.65	11.68	effect
Bme	II	4.34	5.01	5.53	**	12.34	12.20	10.93	N.S.
	III	4.22	4.81	5.41		11.55	11.79	10.43	

Notes: AIR – average intensity in individual rounds, AIB - average intensity of the Burpee in individual rounds, B7 - Burpee performed every 7 seconds, B6 - Burpee performed every 6 seconds, B5 - Burpee performed every 5 seconds, Bs - slow execution, Bf - fast execution, Bme - maximum effort execution.

The fatigue index increased significantly even with the changing execution speed $F(2, 26) = 8.60$, $p < .01$ and with the increasing number of repetitions $F(2, 26) = 12.16$, $p < .01$. When assessing the average height of the vertical jump during the burpee, one can observe a significant increase in connection with the increasing speed of execution $F(2, 26) = 290.29$, $p < .01$, however, the height of the jump did not change significantly $F(2, 26) = 0.66$, $p > .05$ with the increasing number of repetitions (Tab. 2).

Tab. 2 Index of fatique and average jump height during the research

		IF			Anova	AJH			Anova
type	round	B7	B6	B5	two factor	B7	B6	B5	two factor
	I	3.60	1.63	7.64		2.97	2.82	2.65	
Bs	II	-2.86	-4.13	0.56	Bs-Bf-Bme	2.80	2.32	1.94	Bs-Bf-Bme
	III	-4.13	-3.27	4.63	effect	2.26	2.40	1.68	effect
	I	-11.67	-6.53	-3.22	**	8.25	9.78	9.78	**
Bf	II	-2.53	-2.22	0.46		7.15	8.37	9.18	
	III	-12.80	-8.45	12.43	B7-B6-B5	6.35	8.62	8.47	B7-B6-B5
	I	-2.29	4.02	13.31	effect	11.86	10.35	10.28	effect
Bme	II	-1.83	13.47	24.63	**	9.9	11.26	10.93	N.S.
	III	-8.18	7.83	7.89		10.3	9.15	9.89	

Notes: IF – fatigue index, AJH – average jump height in individual rounds

When monitoring the heart rate, a significant increase in both the average and maximum values was noted when the speed of the Burpee changed, i.e. $F(2, 26) = 23.99$, $p < .01$, and/or $F(2, 26) = 75.55$, $p < .01$, as well as with the increasing number of repetitions $F(2, 26) = 9.43$, $p < .01$ or $F(2, 26) = 39.24$, $p < .01$ (Tab. 3).

Tab. 3 Average and maximum heart rate during the research

			AHR		Anova		MHR		Anova
type	round	B7	B6	B5	two factor	B7	B6	B5	two factor
	I	109	119.71	131		120	134	147	
Bs	II	118	133.93	141	Bs-Bf-Bme	127	145	154	Bs-Bf-Bme
	III	120	137,35	145	effect	128	147	156	effect
	I	121	132,18	135	**	138	150	156	**
Bf	II	131	139,63	146		139	150	158	
	III	134	144,21	151	B7-B6-B5	142	153	159	B7-B6-B5
	I	145	139,17	149	effect	160	156	161	effect
Bme	II	153	153,38	158	**	162	163	168	**
	III	153	152,42	156		163	160	162	

Notes: AHR – average heart rate, MHR – maximum heart rate

Shapiro-Wilk test demonstrated a deviation from the multivariate normality of the data distribution $W = 0.88; p = 0.004$. When examining the links between the variables, we can conclude that the average intensity of the burpee did not show a significant relationship with the fatigue index *rs* (52) = .28, *p* > .05. Quite the opposite was the case in the relationship with the average jump height where the strongest among the observed relationships was identified: *rs* (52) = .95, *p* < .01. Significant relationships were also demonstrated with the average and maximum heart rate during the Burpee Movement Program *rs* (52) = .59ss61, *p* < .01, and/or *rs* (52) = .72, *p* < .01. The average intensity values during the round showed significant relationships with all parameters with the fatigue index *rs* (52) = .47, *p* < .01, average jump height *rs* (52) = .80, *p* < .01 and average and maximum heart rate *rs* (52) = .74, *p* < .01 and/or *rs* (52) = .80, *p* < .01 (Fig. 3).

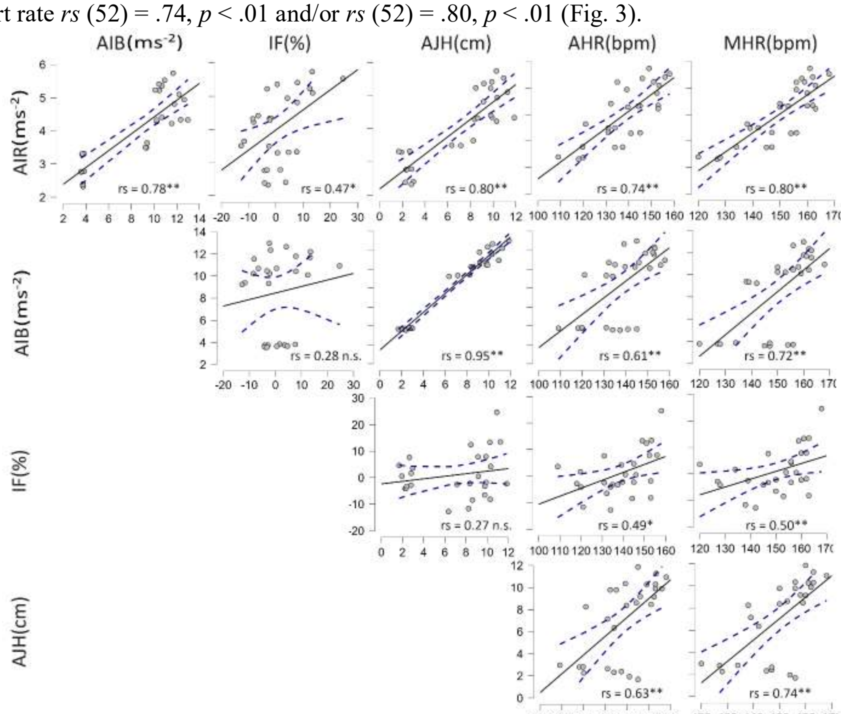

Fig. 3 Relationships between individual parameters

Discussion

The goal of our paper was to objectively evaluate the possibilities of assessing motor performance using the PHYPHOX mobile app. Our research is the first to comprehensively assess a certain training tool. The vast majority of the population owns a mobile phone (Kazi, 2021) and nowadays, it is used in various ways during physical activities. The simplest form of utilization is through applications offering various timers, whether for Tabata, HIIT workouts, or more complex ones that simulate standardized tests such as the Leger beep test or the yo-yo intermittent test (Yu, 2018). With the GPS system in a mobile phone, we can also monitor running speed, distance covered, and more (Gordon, 2016). Recently, the use of the accelerometer in mobile phones has gained significant importance, whether for tracking daily activities (Ariff, 2021), counting repetitions of exercises such as squats, push-ups, or burpees and their diarization (Morris, 2014; Biagetti, 2018), as well as attempts to quantify the intensity of physical activity (Pernek, 2015). If a mobile phone can be used to assess motor performance or monitor progress during a physical activity, it will be most beneficial in the field of sports, but also to sustain a healthy lifestyle. In the previous research (Šiška, 2024), we presented the possibilities of using a mobile phone in assessing the intensity of execution of the Burpee, and the results are practically applied in our current research.

Compared to the previous research, we used a different mobile phone with a different frequency of recording values, but we can state that the achieved results are similar. This fact suggests that the type of mobile phone as well as the number of recorded acceleration values per second do not affect the achieved results. We designed the Burpee Movement Program (BMP) based on the principle of high-intensity interval training (HIIT), consisting of repeated execution of the Burpee at a sound signal at regular intervals. When designing this program, we were inspired by the works of Hatfield (2003) and Oeurgui (2015) who created a short movement program for the duration of a boxing and kickboxing match, which was also the case in our design. There are numerous examples for creating HIIT. According to available literature, the duration of load intervals ranges from 30 s to 2 min. with the work-to-rest ratio most often given from 2:1 to 1:2. The intensity of the load is most often characterized as a percentage of VO2max or Hrmax (Buchheit, 2013; Leite, 2023; Marriott, 2021). In the work of Mayr Ojeda (2022) and Perez-Ifran (2023), the load interval was up to 5 s, but it was followed by a long rest interval of 30 or 35 s, respectively. In our case, we worked with shorter load intervals, which had a duration of 2 to 4 s depending on the conditions, with the work-to-rest ratio varying from 1:2 to 4:1 at intensities >60% Hrmax to >90% Hrmax. In addition, we also recorded the progress data with a mobile phone through acceleration values.

Our first goal was to develop a methodology for assessing performance from the data and verify the reliability of the selected method based on repeated measurements. When evaluating the specific program, we put emphasis on the ability to identify a higher number of performance parameters. By observing one repetitive exercise, we received a certain amount of data from which it was possible to define the entire course of the load. Information about the intensity of an individual repetition can shed some light on the strength-speed properties of the test subject, and we can also assess whether the performance has increased or decreased (fatigue index) in the context of the entire program, which can help us identify the endurance readiness of the test subject. If we focus on the diagnosis of specific motor performance, we did not find a study that proceeded in a similar manner. Mainly in the field of combat sports, specific tests are carried out. More or less, various techniques and their combinations are used in a repeated execution regime for a certain period (Chaabene, 2018). In the mentioned research, however, the intensity of exercise execution was not directly controlled. As we mentioned at the beginning, the Burpee exercise was also used as part of a motor test. Over a period of 30 s (Kojic, 2021) or 3 min. (Podstawski, 2013), it was necessary to perform as many repetitions as possible, also without assessing individual repetitions. In our research, we primarily focused on being able to accurately quantify each repetition. The BMP program was also modifiable both in terms of volume and intensity, which to a large extent can affect its possible use by the general population. The very changing intensity could hint at whether the mobile phone is able to identify this change or not. The first assumption was that the intensity throughout the round had to increase with the increasing speed of the Burpee and the number of repetitions. However, within one program – especially at a lower intensity – it should not change significantly in individual rounds. This fact was confirmed. We can also notice that in slow execution of the individual variants, the intensity for the whole round differed in the hundredths. The differences were more noticeable at a fast pace and with maximum effort where fatigue could have already played a role. The second assumption was that the intensity of a single repetition of the Burpee must increase with respect to the speed of execution, but should not change significantly with the increasing number of repetitions. Even this fact was confirmed. We chose the heart rate, which can reliably reflect the intensity of the load (Urbina, 2022), and the jump height during the Burpee as control parameters. Similar to the average round intensity, the heart rate increased with the changing intensity of execution and increasing number of repetitions. In contrast, the average jump height followed the development of average intensity of the Burpee, and the strongest correlation was established between these two parameters. However, other variables showed a stronger correlation with the average intensity during the round. This could be due to the fact that the average intensity throughout the round increased proportionally, which was also the case in the heart rate, and on the other hand, there was a more significant difference between the slow (approx. 4 ms^{-2} or 3 cm) and fast execution (approx. 10 ms^{-2} or 8 cm) in the average intensity of the Burpee and jump height.

Significant relationships between the intensity measured on the mobile phone, heart rate, and the Burpee jump height indicate that this type of measurement can reliably assess the intensity of exercise. Of course, this claim needs to be verified on a larger research sample. The parameter of fatigue index remains questionable, which seems very important for assessing the course of exertion. However, during analysis, it did not show the desired correlation with other monitored parameters, and this fact needs to be subjected to deeper analysis. We also presented the overall fatigue index for all three rounds combined, which seems to be a possible starting point, and its assessment needs to be focused on in further research. The reliability of using an accelerometer for measurements is crucial in sports applications and depends on various factors that must be considered during selection and use. Accelerometers generally show good intra-instrument reliability, but substantial differences between units require either unit-specific calibration or statistical adjustment (Brage, 2003).

On the other hand, Kelly (2015) noted that accelerometers have excellent intra- and interaccelerometer reliability. Nevertheless, both static and dynamic validity were lacking, and it is recommended to exercise caution when measuring absolute acceleration, especially for high-frequency movements. Our study was based on Henriksen's (2004) work, which measured the test-retest reliability of trunk accelerometric gait analysis during walking using a triaxial accelerometer mounted on the lumbar spine. Following Mukaino's (2022) methodology, we incorporated control parameters, which enabled us to evaluate the reliability of the selected method from this standpoint. If we evaluate the use of BMP as a motor test, we can state that the Burpee exercise itself is relatively easy to control, and the method of its quantification also appears to be reliable. In the future, it is necessary to focus on defining the relationships of performance in BMP to standardized strength and endurance parameters as an expression of test validity and to perform measurements on the widest possible population sample. If we focus on the BMP as a training tool without measuring intensity, we can state that it is a slightly atypical form of HIIT training but very simple to implement. Considering the warm-up and the final part, e.g., stretching, the entire training unit can last from 30 to 45 minutes, which is, in our opinion, an ideal time range. As we have already mentioned, BMP is modifiable in terms of execution intensity (Burpee speed) as well as volume (number of repetitions). The program can also be modified by adding additional load in the form of a weighted vest or by adding a certain movement between repetitions. By extending the intervals, e.g., to 20 seconds, the Burpee exercise can be replaced with the strength exercise clean and jerk, resulting in a completely new form of BMP. The authors state that this type of exercise has an impact on various motor and physiological parameters. Significant improvement was recorded in body mass index (Liu, 2022), flexibility (Masagca, 2024), aerobic and anaerobic capacity ((Milioni, 2024, Wu, 2023), and also, blood pressure (González-Gálvez, 2024). A similar impact can be expected with BMP, but this claim will need to be credibly verified.

Conclusion

We conclude that we successfully managed to demonstrate the possibilities of using a specific Burpee Motion Program based on the HIIT principle, propose a methodology for assessing the performance using a mobile phone and verify the reliability of this method. The results of our research will be used in the practical application of the Burpee Movement Program (BMP).

This paper is part of the VEGA* 1/0482/21 research grant *"Standardization of specific short-interval load as a motor test of strength-endurance abilities in combat sports"

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