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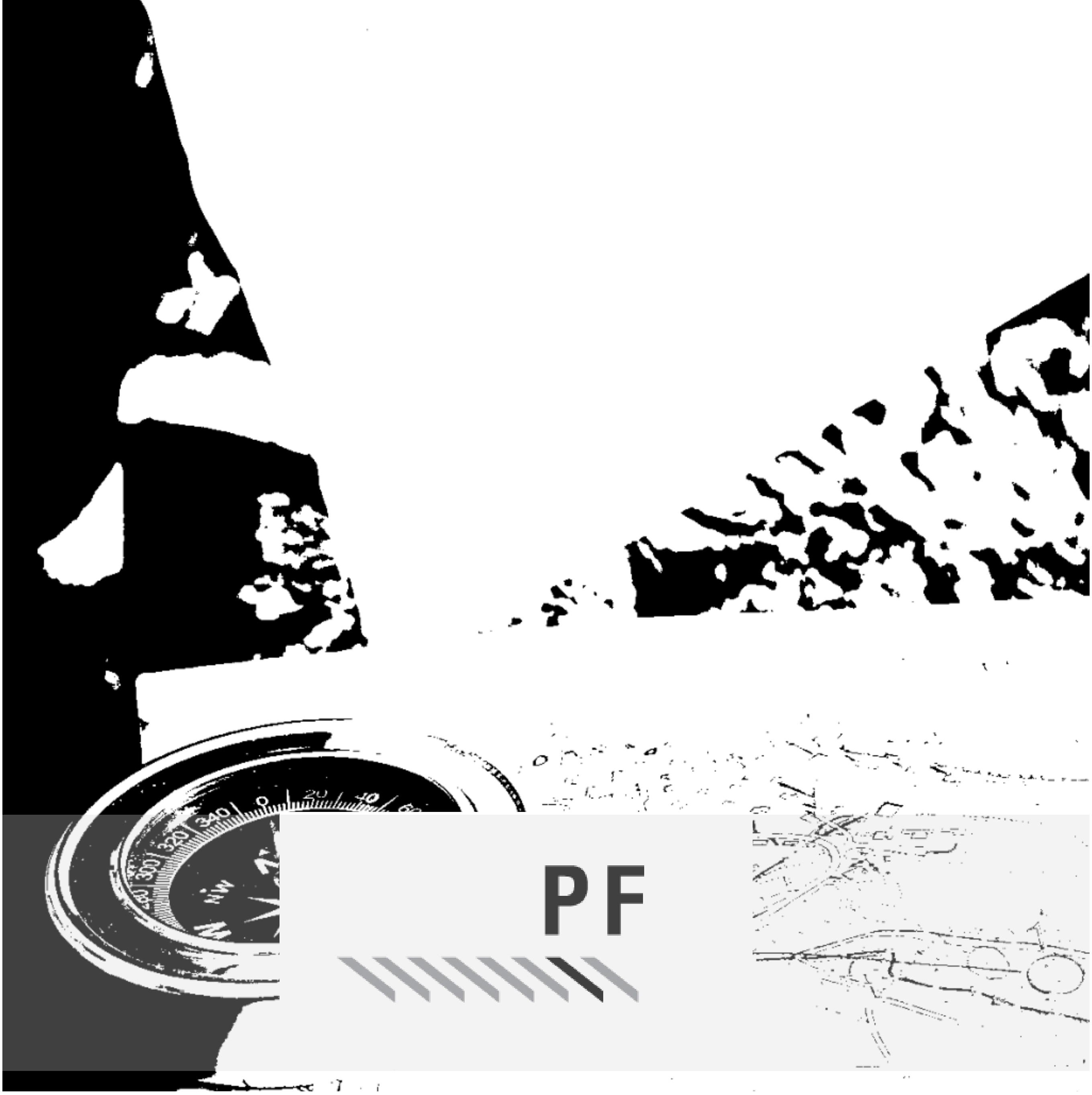

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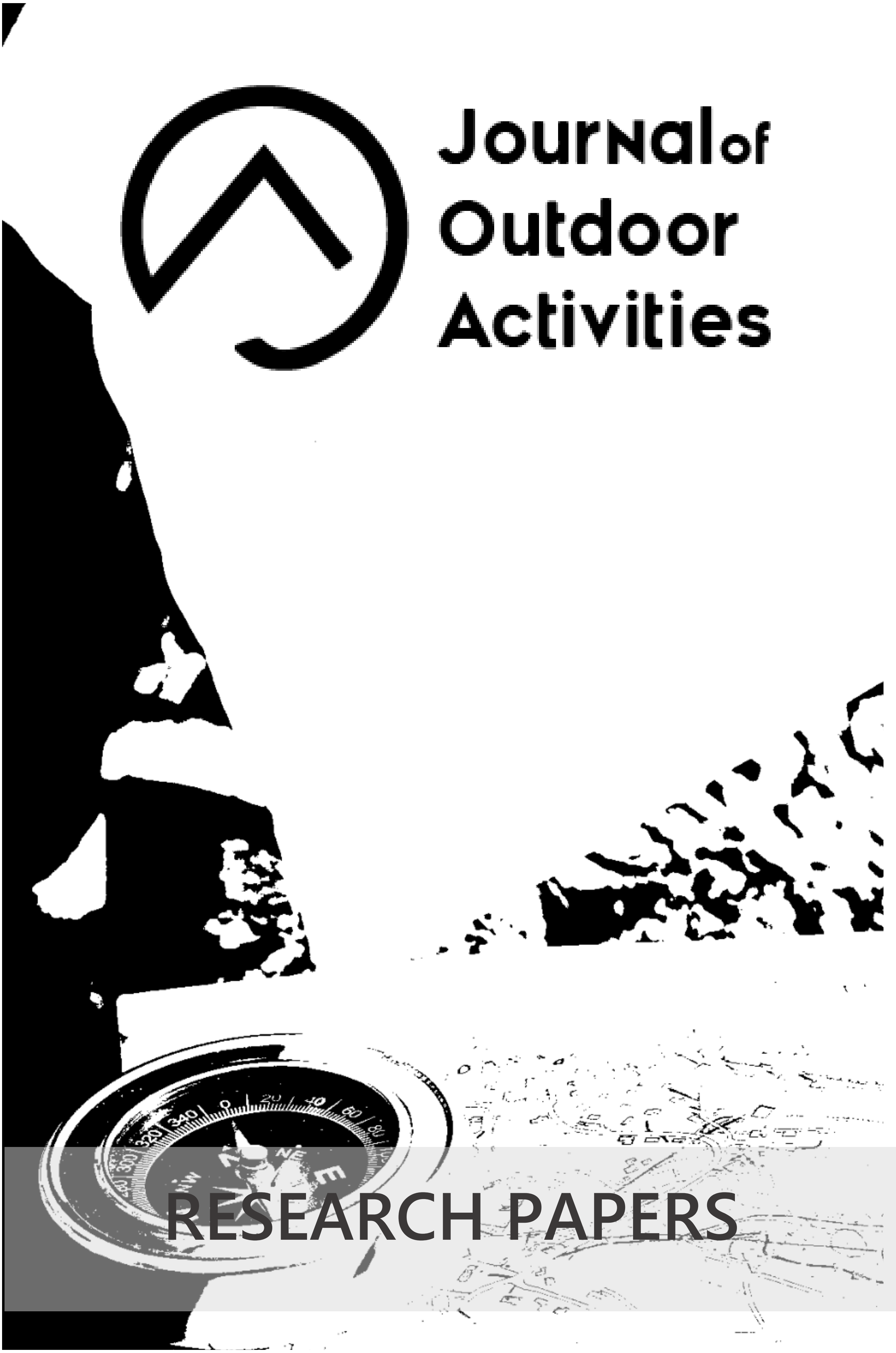

RESEARCH PAPERS

Determining the Degree of Load on the Body by Monitoring the Heart Rate in Ball Hockey in Men's Extra-League Matches

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Czech ball hockey, Czech Republic

ABSTRACT
Introduction: Ball hockey is a young, progressively developing sport that lacks research into players' loads in competitive matches. As far as we know, our work is the first.
Aim of Study: The work aims to solve the problem of determining the degree of load during a ball hockey match by monitoring and analyzing heart rate in selected matches of the extra league of ball hockey.
Material and Methods: The sample included ten ball hockey players (age 25 ± 5.21 years, height 184.2 ± 6.8 cm, weight 83.8 ± 11.48 kg) from three extra-league clubs in the positions of forwards (8) and defenders (2). The sample was monitored in six extra-league matches of the basic part of the seasons 2019-2020 and 2020-2021. Determination of the maximum heart rate (SF_{max}) was performed by the protocol of a modified Conconi test (Hnízdil, 2006) performed on an HP Cosmos Venus running ergometer (HP Cosmos Sports and Medical, Germany), which the test subjects completed in wrestling equipment without a ball hockey stick. According to Ben Abdelkrim et al. (2010), individual intensity zones were determined based on SF_{max} results. Heart rate measurement (SF) was performed by Polar Team 2 (Polar O.Y., Kempele, Finland), which records and stores SF in beats.min-1 for five seconds. The documentation of the matches was done with a Sony HDR-XR155E camcorder; the chronometer was made using a Secco stopwatch and a stopwatch on a mobile device. Video played in VLC player (Free Software Foundation, Inc., Boston, USA), SF evaluated in Polar Precision Performance 4.03.040 (Polar, OY, Kempele, Finland), and basic data processing was performed in Excel (Microsoft Corporation, California, USA).
Results: The ball hockey player moves on average in the extra league match 3.4% of the time in the zone above 95% SF_{max}, 22.8% of the time in the zone 85-95% SF_{max}, 25.4% of the time in the zone 75-84.99% SF_{max} and 48, 4% of the time in the zone below 75% SF_{max}. When changing to rest on the inverter, its load is in the ratio of 1: 2.9.
Conclusion: Our work is based on empirical findings brought by specific procedures for improving the training process. The limit of the work is the relatively low number of monitored matches and the low number of defenders. The work can be followed by detecting the load by more invasive methods ($VO2_{max}$, lactate), by detecting the

external load or by detecting the activity of the muscles in the load using EMG, or by searching for relationships between individual phenomena.
Keywords: Physiological load, Ball Hockey, Heartrate

SOUHRN

Úvod: Hokejbal je mladý progresivně se rozvíjející sport, kterému chybí výzkumná šetření odhalující zatížení, které podstupují hráči v soutěžních zápasech. Pokud je nám známo, je naše práce v tomto směru první.

Cíl: Cílem práce je přispět k řešení problematiky stanovení míry zatížení v průběhu hokejbalového utkání, prostřednictvím monitoringu a analýzy srdeční frekvence u vybraných utkáních extraligy hokejbalu.

Metody: Výběrový soubor zahrnoval 10 hráčů hokejbalu (věk 25 ± 5,21 let, výška 184,2 ± 6,8 cm, váha 83,8 ± 11,48 kg) ze tří extraligových klubů na pozicích útočníci (8) a obránci (2). Výběrový soubor byl sledován v šesti extraligových zápasech základní části sezón 2019-2020 a 2020-2021. Před provedením výzkumného šetření byly získány informované souhlasy testovaných osob (dále jen TO), souhlasy hlavních trenérů dotčených klubů a souhlas Českomoravského svazu hokejbalu (dále jen ČMSHb) k provedení výzkumu. Stanovení maximální SF (dale jen SF_{max}) provedeno v laboratoři zátěžové diagnostiky Univerzity Jana Evangelisty Purkyně v Ústí nad Labem a to prostřednictvím modifikovaného Conconiho testu (Hnízdil, 2006). Individuální intenzivní pásma byla stanovena podle Ben Abdelkrim et al. (2010) na základě výsledků SF_{max}. Pro měření srdeční frekvence (dále jen SF) byl využit systém Polar Team 2 (Polar O.Y., Kempele, Finsko), který zaznamenává a ukládá SF v tepech.min^{-1} po pěti sekundách. Zadokumentování zápasů provedeno videokamerou Sony HDR-XR155E, chronometráž provedena pomocí stopek zn. Secco a stopek na mobilním zařízení. Videozáznam přehrán v programu VLC player (Free Software Foundation, Inc., Boston, USA), SF vyhodnocena v programu Polar Precision Perfomance 4.03.040 (Polar, O.Y., Kempele, Finsko) a základní statistické zpracování dat bylo provedeno v programu Excel (Microsoft Corporation, California, USA).

Výsledky: Hráč hokejbalu se průměrně pohybuje v zápase extraligy 3,4 % času v zóně nad 95 % SF_{max}, 22,8 % času v zóně 85 – 95 % SF_{max}, 25,4 % času v zóně 75 – 84,$\overline{9}$ % SF_{max} a 48,4 % času v zóně pod 75 % SF_{max}. Jeho zatížení při střídání k odpočinku na střídačce je v poměru 1:2,9.

Závěr: Naše práce se opírá o empirická zjištění na jejichž základě přináší konkrétní postupy jak zkvalitnit tréninkový proces. Limitem práce je relativně nízký počet sledovaných utkání a nízký počet obránců. Na práci lze navázat zjišťování zatížení invazivnějšíma metodama (VO_{2max}, laktát), zjišťováním vnějšího zatížení nebo

odhalováním aktivity svalů v zátěži pomocí EMG a nebo hledáním vztahů mezi jednotlivými fenomény.

Klíčová slova: Fyziologické zatížení, Hokejbal, Srdeční frekvence.

INTRODUCTION

Team sports are a phenomenon of contemporary society. The best teams in the world watch millions of spectators. There is a relatively significant difference in the popularity and support of team sports, which is reflected in their development. Ball hockey is a relatively young sports game that is looking for its place in the limelight of world sports. It is based on ice hockey (Perič, Přerost, & Kadaně, 2006) and is classified as a collective, invasive, goal team sport (Lehnert et al., 2014). The specificity of ball hockey is the rule of the floating offensive zone defined according to the rules of the Czech-Moravian Ball Hockey Association (2018) as follows: "If the ball is introduced or passed behind the offensive blue line, "Floats" to red)" (p. 46). In the specialized literature (Perič et al., 2006; Pek 1998) the load in ball hockey is, in our opinion, insufficiently described in comparison with other intermittent team sports such as ice hockey (Bukač & Dovalil, 1990; Havlíčková, 1993; Stanula & Roczniok, 2014), floorball (Kysel, 2010), handball (Lehnert et al., 2014), basketball (Havlíčková, 1993; McInnes, Carlson, Jones, & McKenna, 1995; Lehnert et al., 2014) or futsal (Barbero - Alvarez, JC, Soto, Barbero-Alvarez, V., & Granda-Vera, 2008; Hůlka et al., 2014; Weisser, Bělka, Hůlka, Houdková, & Koruna, 2012). It cannot be otherwise because research investigations aimed at revealing the load in ball hockey are absent. Clarified phenomena from exercise physiology generally apply to ball hockey, and knowledge from ice hockey is adopted (Pek, 1998; Perič et al., 2006). Pek (1998) specifies the load in ball hockey as follows: "aerobic processes reach 80-90% of maximum values and SF reaches 87-92% of maximum" (p. 151). Hůlka et al. (2014) and Lehnert et al. (2014) state that the load in team sports can be monitored based on the parameters of the work performed (external load) and according to the organism's response to this load (internal load). The most suitable and one of the most available methods of internal load analysis is SF measurement (Süss, 2006).

SF is a designation for the rate of work of the heart muscle given in the number of contractions per unit time, most often beats.min-1 (Dong, 2016). The activity of the heart muscle is driven by electrical stimuli, which arise involuntarily in the pacemaker (sinus node) and are controlled by the autonomic nervous system (ANS). Increasing the excitation rate causes sympathetic ANS, and decreasing the rate of excitation causes parasympathetic ANS (Merkunová & Orel, 2008). SF is affected by several factors that affect its values. These factors include age (Hnízdil, 2011; Nes, Janszky, Wisløff, Støylen, & Karlsen, 2012; Zahradník & Korvas, 2012), gender (Benson & Connoly, 2011), heart size and athletic performance (Novotný, 2017; Žiška , Olasz & Krčmár, 2016), psychoemotional load (Havlíčková et al., 1994; Hnízdil, 2011; Merkunová & Orel, 2008), drinking regime and nutrition (Hnízdil, 2006, 2011; Hnízdil et al., 2012; Safarian, Charrière , Maufrais, & Montani, 2019), pharmaceuticals (Hnízdil, 2006, 2011; Proud 2006), medical condition (Filarecka & Biernacki, 2018), body position (Abad et al., 2017; Hnízdil, 2011; Jeukendrup & Van Diemen , 1998; Rendos, Musto & Signorile, 2015; Vujkov, Casals, Krneta, & Drid, 2016; Watanabe, Reece & Polus, 2007), ambient temperature (Malcolm, Cooper, Folland, Tyler, & Sunderland, 2018; Pilch et al. ., 2019), altitude (Bhattarai et al., 2018; Jereb & Burnik, 2010) and aquatic environment (Alberton & Kruel, 2009; Thiel & Sýkora, 2016). These factors are not the only methodological problem in measuring SF. Load intermittency comes into play, causing a delay of up to 30 seconds in the current SF (Lehnert et al., 2014).

In order to determine the load according to SF, it is necessary to know SF_{max} (Süss, 2006). This value can be accurately measured using standardized stress tests performed in a laboratory environment on certified facilities (Heller, 2018; Hnízdil, 2011). The so-called intensive zones were developed for the needs of team sports (Table 1). They are most often built into different SF_{max} percentage zones (Ben Abdelkrim et al., 2010; Da Silva et al., 2018; Hůlka et al., 2014; Lehnert et al., 2014; McInnes et al., 1995; Tessitore et al., 1995; ., 2005; Vencúrik, Nykodým, & Vacenovský, 2016), less often to SF values in the $VO2_{max}$ percentage zones (Lucia, Hoyos, Carvajal, & Chicharro, 1999; Santalla, Earnest, Rodriguez-Marroyo, & Lucia, 2012) and sometimes you can also find the division of the zones into individual beats (Agraj, 2005; Bílek, 1983; Capranica, Tessitore, Guidetti, & Figura, 2001). Some studies manifest results by average SF per match (Ali & Farrelly).

Table 1. Heart Rate Zones Types

Form[a]	Marker	Intensive Zones Range												
1	SF_{max}	< 85 %	> 85 %											
2	SF_{max}	< 65 %	65 – 85%	> 85 %										
3	SF_{max}	< 85 %	85 – 95 %	> 95 %										
4	SF_{max}	< 75 %	75 – 84 %	85 – 95 %	> 95 %									
5	SF_{max}	50 – 60 %	60 – 70 %	70 – 80 %	80 – 90 %	> 90 %								
6	SF_{max}	< 70 %	71 – 85 %	86 – 90 %	91 – 95 %	> 95 %								
7	SF_{max}	< 75 %	75 ≤ 80 %	80 ≤ 85 %	85 ≤ 90 %	90 ≤ 95 %	≥ 95 %							
8	VO_{2max}	SF < 70 %	SF 70 – 90 %	SF > 90 %										
9	VO_{2max}	SF < VT_1	SF VT_1 – VT_2	SF > VT_2										
10	$t.m^{-1}$	< 150	> 150											
11	$t.m^{-1}$	< 120	121 – 140	141 – 160	161 – 180	181 – 200	> 201							
12	$t.m^{-1}$	<110	110	120	130	140	150	160	170	180	190	200	210	>210

SF = heart rate; SF_{max} = maximal heart rate; VO_{2max} = maximal oxygen consumption; $t.m^{-1}$ = beats per minute; VT_1 = aerobic ventilation threshold; VT_2 = anaerobic ventilation threshold.
[a] Form 1 according to Tessitore et al. (2005), 2 according to Lehnert et al. (2014), 3 according to Vencúrik et al. (2016), 4 according to Ben Abdelkrim et al. (2010), 5 according to Hůlka et al. (2014), 6 according to Da Silva et al. (2018), 7 according to McInnes et al. (1995), 8 according to Santalla et al. (2012), 9 according to Lucia et al. (1999), 10 according to Bílek (1983), 11 according to Agraj (2005), 12 according to Capranica et al. (2001).

The values obtained by monitoring SF serve as an estimate of the load and do not indicate the type of load (locomotion and involvement of the main muscle groups). In addition, load intermittency overestimates energy expenditure by 5 to 20% (Hůlka et al., 2014). Ventilation appears to be a better indicator for estimating energy expenditure (Gastinger, Sorel, Nicolas, Gratas-Delamarche, & Prioux, 2010), which is not feasible for application to competitive matches. Nevertheless, even though SF monitoring is burdened with methodological problems, it is the most widely used method of internal load analysis in a match (Hůlka et al., 2014).

MATERIAL AND METHODS

Participants

The group included ten players (age 25 ± 5.21 years, height 184.2 ± 6.8 cm, weight 83.8 ± 11.48 kg) from three clubs in the positions of offenders (8) and defenders (2). We monitored the tested persons (TP) in six competitive ball hockey matches of the extra senior league of the Czech Republic in the seasons 2019-2020 and 2020-2021. To maintain anonymity, abbreviations TP1-10 were created for TP. The group was selected by a combination of intentional selection and selection methods based on voluntariness in self-selection (Reichel, 2009). Prior to the commencement of the research survey, the tested persons were informed of the risks associated with the conduct of the research, and they signed informed consent. Furthermore, because they are registered with the parent club, consent was obtained for their participation with the head coaches of the clubs concerned.

Research design

SF load zones were determined for load assessment according to Ben Abdelkrim et al. (2010). The baseline value for the calculation of intensive zones was SF_{max} determined by laboratory testing, and where the SFmax value exceeded the value from the laboratory test, the newly obtained SFmax was used. All SF measurements at the test persons (TP) were performed with the Polar Team 2 system (Polar O.Y., Kempele, Finland), which stores SF values in beats.min-1 in the chest receiver after five seconds.

Laboratory testing took place in the functional diagnostics laboratory of the Department of Physical Education and Sport, Jan Evangelista Purkyně University in Ústí nad Labem. Prior to laboratory testing, TPs were asked to refrain from alcohol, drug use, increased physical activity 24 hours prior to testing, and stop eating 2 hours before testing. According to our information, each TP has encountered training in the same type of equipment in the past. One of the standardized test requirements is the specificity, which we tried to increase by dressing the TP in complete ball hockey equipment without a ball hockey stick. Some players play shin guards, and some do not. Their use in the test depended on their wearing during matches. Thus, the testing took place in sportswear, which was increased by a helmet, gloves, and, in some players, razors.

TPs started a warm-up, which took place on a running ergometer. The warm-up lasted 8 minutes, when it was divided into two consecutive speed sections, with the first section being 4 minutes long with a speed of 9 km.h-1 and the second 4 minutes long with a speed of 11 km.h-1. Subsequently, the muscle parts were warmed up and switched to a test motorized running ergometer HP Cosmos Venus (HP Cosmos Sports and Medical, Germany), on which a modified Conconi protocol with a fixed distance was set (Hnízdil, 2006). The inclination of the ergometer belt was set to 1%, which compensated for the resistance of the environment. The starting speed is set at 11 km.h-1, when after every 150 meters, the belt speed increases by 0.5 km.h-1. The test took place until the subjective exhaustion of the TP.

The match measurement took place in the official matches of the ball hockey extra league, and the approval of the ČMSHb was obtained for the transparency of the research. Before each match, the leading referees were informed about the ongoing research. They were also told that players with unique markings on their helmets are participating in the research (consent to the placement of these markings was obtained from the ČMSHb technical committee).

Because the Polar Team 2 system cannot record the split times entered by the distance evaluator, a basic timeline was created, measured with a Secco stopwatch, and checked the accuracy with a stopwatch on a mobile phone. For the future synchronization of measuring and monitoring devices, a record sheet was created, in which the split times of the monitored phenomena were recorded (activation of each chest receiver, beginning, and end of each third). The measurement took place in such a way that a meeting with the TP took place in the range of one to an hour and a half before the match (a time chosen so that the TP would not interfere with the warm-up and focus on the match), during which the chest straps were fastened. Subsequently, the optimal place was found to place a recording device with a good view of the stadium's inverters. Monitored matches were recorded on a Sony HDR-XR155E camcorder with a tripod and its memory, which was turned on before the start of each third and turned off after the end of each third to save battery power. After the match, a meeting took place with the TP, at which the monitoring was completed (switching off the receiver and stopwatch).

Data processing

Data from laboratory testing and monitored matches were transferred to a laptop, from which SFmax values and SF values from matches were obtained. The videos were played in the VLC player program (Free Software Foundation, Inc., Boston, USA), in which the start and end times of the periods and the beginning (entry to the course, standard) were searched for and recorded in Excel (Microsoft Corporation, California, USA), interruption and end of rotation (entry to the substitute, referee's whistle). In Excel, the basic timeline was used to convert the times of these phenomena to the times recorded in the chest receivers. After synchronization, these phenomena, together with the intense zones, were entered into the Polar Precision Performance 4.03.040 program (Polar, O.Y., Kempele, Finland), in which the results of the time spent in each zone for each player for each match were evaluated. Basic data processing is performed in Excel. We interpret the results of intensive zones as a percentage of time spent in individual zones. We interpret other results as mean values (M) ± standard deviation (SD).

In order to interpret the results, it was necessary to establish some deadlines on which the results are based. The insertion of the introductory bully defines the beginning of the period. The end of the period is defined by the referee's whistle, after which the break occurs. The start of substitution is defined as when the ball is thrown or running onto the court during a free substitution. The end of the substitution is defined by running out of the court in a free substitution or by the referee's whistle, after which the player was replaced. The net time of the game is limited to the beginning and end of the substitution and does not include the time spent between the referee's whistle and the subsequent throw-in. The time in the match is limited to the beginning and end of the periods, so it does not include the time of breaks between the thirds. In the study, we monitored selected phenomena that are defined by the value of SF at individual moments of the beginning of periods (insertion of the introductory bully), beginning and end of the rotation, culmination of SF (moment of the highest SF value recorded from the beginning of rotation to beginning of next rotation). The average rest period is defined by the elapsed time from the end of the run to the beginning of the run. Finally, the average length of the rotation is limited by the beginning and end of the rotation.

RESULTS

The work aimed to contribute to the solution of determining the degree of load during a ball hockey match by monitoring and analyzing heart rate in selected matches of the ball hockey extra league.

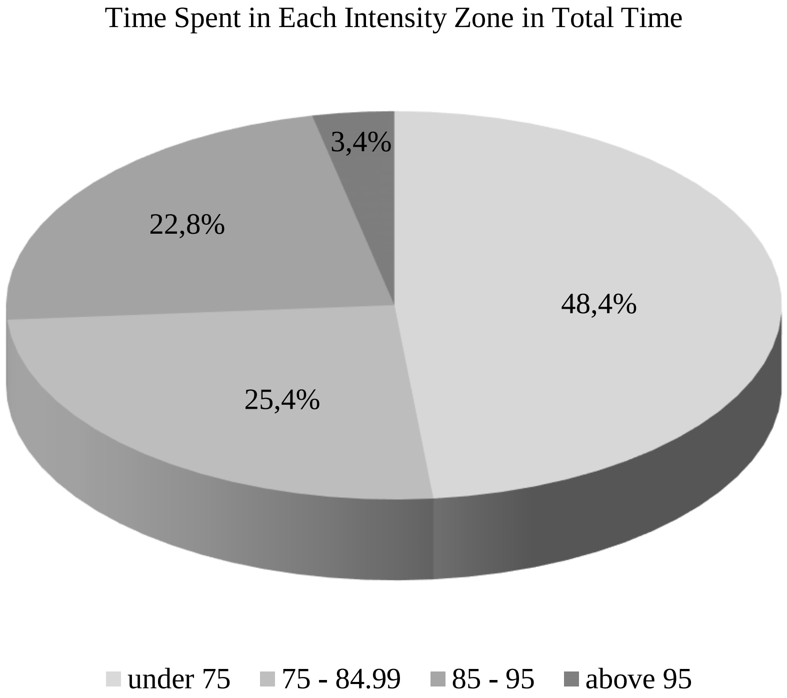
Table 2 interprets individual intensive zone calculations from laboratory testing results and increased SF values from matches.

Table 2. Range of Individual Heart Rate Values in Intensive Zones

TP	Intensity Zones in % SF_{max}					
	< 75	75 – 84.$\overline{9}$9	85 – 95	> 95	$SF_{max}1$	$SF_{max}2$
TP1	< 139.5	139.5 – 158.0	158.1 – 176.7	> 176.7	186	
TP2[a]	< 151.5	151.5 – 171.6	171.7 – 191.9	> 191.9	202	
TP3	< 143.3	143.3 – 162.3	162.4 – 181.5	> 181.5	191	
TP4	< 145.0	145.0 – 164.8	164.9 – 184.3	> 184.3	194	
TP5	< 138.0	138.0 – 156.3	156.4 – 174.8	> 174.8	184	
TP6	< 156.0	156.0 – 176.7	176.8 – 197.6	> 197.6	207	208
TP7	< 140.3	140.3 – 158.9	159.0 – 177.7	> 177.7	184	187
TP8	< 146.3	146.3 – 165.8	165.8 – 185.3	> 185.3	191	195
TP9[a]	< 152.3	152.3 – 172.5	172.6 – 192.9	> 192.9	203	
TP10	< 140.3	140.3 – 158.9	159.0 – 177.7	> 177.7	187	

Values are given in beats.min^{-1}; SF_{max} = maximal heart rate; $SF_{max}1$ = results of laboratory testing, $SF_{max}2$ = maximum from the match.
[a] *The player is the defense player.*

In team sports, the results of intensive SF zones from the entire match are interpreted, including net playing time, interruptions in the game, and rest on the substitute. In Graph 1, we present the results of our survey, which shows that the ball hockey player moves on average in the extra league match 3.4% of the time in the zone above 95% SF_{max}, 22.8% of the time in the zone 85 - 95% SF_{max}, 25.4 % of the time in zone 75 - 84.99% SF_{max} and 48.4% of the time in the zone below 75% SF_{max}. The average value of SF in the match is at the level of 76.41% SF_{max}, which includes measurements from the beginning to the end of thirds.



Graph 1. Intensive zones of all players in all matches expressed as a percentage of time

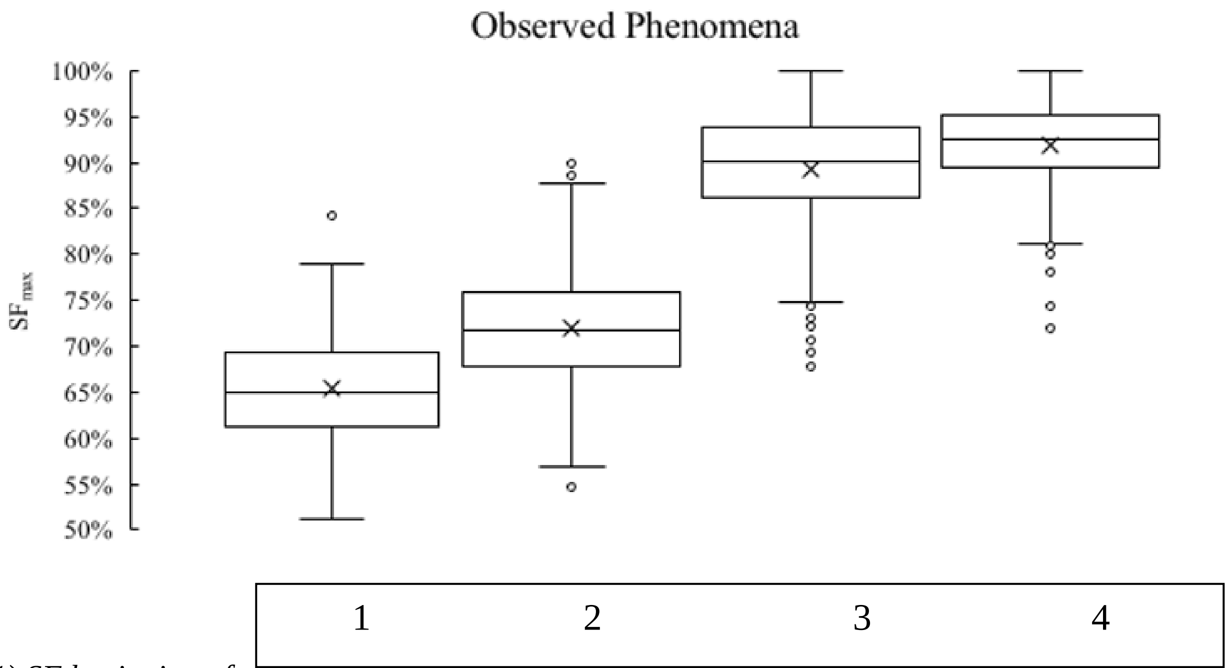
Some studies deal with a more detailed analysis of SF and evaluate the intense zones of SF in the net time of the game, i.e., without taking into account interruptions in the game and rest. In Table 3, we present an evaluation of the net time of the game, from which it is evident that the players are undergoing a somewhat more demanding load than the result of the interpretation of the results of the entire match. To evaluate the net time of the game, we found it interesting to divide the results into offenders and defenders in various game situations such as balanced and unbalanced situations.

Table 3. Time Spent in the Intense Zones of SF Net Game Time

Game Situation	Group	< 75 % SF_{max}	75-84.99 % SF_{max}	85-95 % SF_{max}	> 95 % SF_{max}
Five Against Five	Everyone	21.8	33.5	39.4	5.3
	Offenders	18.5	32.2	42.6	6.7
	Defenders	33.8	38.3	27.6	0.3
Power Play	Everyone	12.1	35.8	43.8	8.3
	Offenders	9.5	32.9	48.0	9.6
	Defenders	28.6	53.8	17.6	0.0
Short-Handed Play	Everyone	21.4	33.7	42.4	2.5
	Offenders	15.3	31.6	49.9	3.2
	Defenders	46.1	42.1	11.8	0.0

Values are given as a percentage of the time spent in the given zone. Own source.

As part of the revelation of some relationships, we were interested in the value of SF in selected phenomena (Graph 2). SF at the beginning of the rotation is at the level of 71.88 ± 6.45% SF_{max}, SF at the end of the rotation is 89.33 ± 5.93% SF_{max}, and the culmination of SF reaches an average of 91.89 ± 4.52% SF_{max}. The culmination of SF in our research occurs after the end of the rotation in an average of 11 ± 6 seconds and increases by an average of 5.96 ± 6.37 beats.min-1. We measured the psychoemotional load at the beginning of the thirds at the moment when the initial bulge was thrown in, and the need for energy expenditure did not cause the increase in SF. The average SF value at the beginning of all periods for all players is 65.46 ± 5.90% SF_{max}. An interpersonal evaluation of the observed phenomena is provided in Table 4.



1) SF beginning of the period;2) SF beginning of the alternation;3) SF end of the alternation;4)SF culmination

Graph 2. SF_{max} Values for Observed Phenomena

Table 4. Interpersonal Values of SF in Selected Phenomena

Phenomena		TP1[a]	TP2	TP3	TP4	TP5	TP6	TP7	TP8	TP9[a]	TP10
SF at the Beginning of the Rotation	M	67.00	66.61	69.82	72.53	76.39	75.25	79.18	72.89	69.61	72.50
	SD	5.04	6.73	3.49	6.33	4.89	5.63	4.47	4.18	4.11	6.06
	Min	54.84	47.03	62.30	54.64	66.30	64.42	64.17	65.64	59.61	63.10
	Max	80.11	78.71	76.44	84.02	88.59	89.90	87.70	85.13	75.86	86.10
SF at the End of Rotation	M	84.83	89.50	88.21	89.15	90.43	94.22	93.85	89.68	87.45	86.87
	SD	5.76	6.07	5.27	5.33	6.46	3.41	3.96	5.84	4.05	5.39
	Min	67.74	69.31	70.68	72.16	75.00	83.64	78.61	73.85	79.80	71.12
	Max	94.62	97.52	95.29	96.91	97.83	100.00	99.47	97.95	94.09	94.12
SF Culmination	M	87.43	92.35	90.68	91.62	97.26	95.24	95.16	91.94	89.87	90.46
	SD	4.87	3.31	4.02	3.23	1.65	2.85	3.45	4.91	3.18	2.91
	Min	72.04	85.64	74.35	83.51	92.93	87.50	81.82	78.46	85.71	82.89
	Max	97.31	97.52	97.38	98.97	100.00	100.00	100.00	100.00	95.57	97.33
SF at the Beginning of the Period	M	60.16	63.09	67.95	65.35	70.47	69.15	71.48	66.58	60.34	65.24
	SD	5.15	5.76	4.07	5.98	12.69	2.52	4.27	3.23	3.81	2.77
	Min	51.08	57.43	62.30	57.73	59.24	64.42	64.14	61.54	53.69	62.57
	Max	68.28	74.26	74.87	78.87	84.24	71.15	75.94	70.77	64.53	70.05

Values are expressed as a percentage of the SF_{max} of a particular TP; TP = test person; M = arithmetic mean; SD = standard deviation; Min = minimum value of all values obtained; Max = value of all values obtained.
[a] The player is the defense player.

As part of the evaluation of the research survey, we came to interesting data that cannot be left out. From the analysis of the obtained data, we found that the player will play an average of 5.90 ± 1.10 substitutions per third and 17.70 ± 1.99 substitutions per match. Therefore, he will play an average of 14:39 ± 02:34 minutes of net time in the match. The average substitution of the player is 01:02 ± 00:37 minutes, of which the net time of the game is 00:50 ± 00:25 minutes. The average rest between rotations is 03:01 ± 01:42 minutes. During the research survey, 407 runs were evaluated, which helped determine the relationship between runs and rest relevant. The ratio of time to rest is 1: 2.9 and was calculated from the average length of rest (181 seconds) and the average length of change (62 seconds).

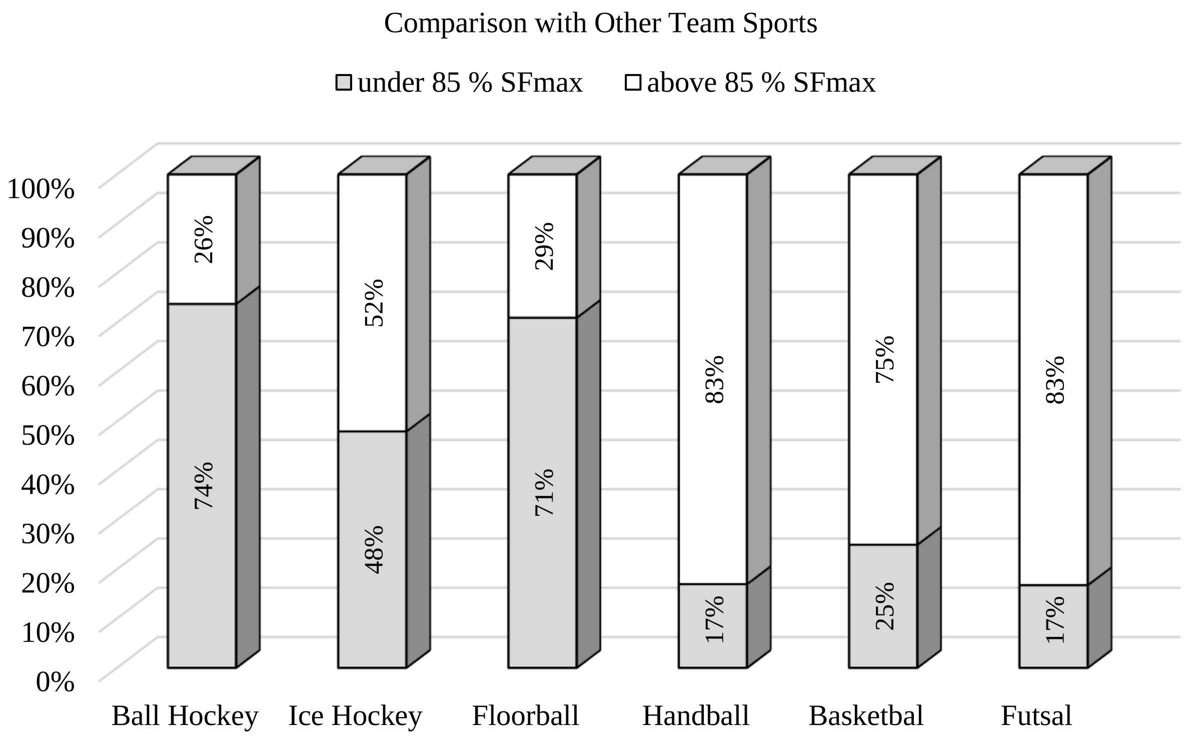
DISCUSSION

This study aimed to analyze the heart rate responses of extra-league ball hockey players in the matches of the basic part of the 2019/2020 and 2020/2021 seasons. Unfortunately, as far as we know, no study has addressed this issue yet.

When obtaining fundamental data, we used laboratory testing as a standardized method for determining SF_{max} values using a running ergometer. We know that the TP must master specific skills resulting from moving on the treadmill (Heller, 2018). During the research, it turned out that the laboratory values measured by us were not their maximum in all persons. Some TPs in the match exceeded the measured SF maximum observed in the laboratory. This can be justified by the high motivational effect on the player during the match (Petráš, 2018) or by an inappropriately chosen test (Santos, Silva, Farinatti, & Monteiro, 2005). We think that this is the motivating factor that increased our SF_{max} values, mainly because no player had a plateau phase in laboratory testing (Heller, 2018; Nes et al., 2012).

We interpreted the results to summarize all the time spent in the match playing. Time spent in the third period is not included in the result. The results show an equilibrium game of five against five and all kinds of power play (5-4, 5-3, 4-3) and short-handed play (4-5, 3-5, 3-4). When interpreting the results, it is necessary to consider the fact that the players played against different opponents who professed different playing styles. It is also necessary to realize that the players had to follow their team strategy, the strategy of their line, and their position. Each of the players had different team tasks, and he was differently included in the game and different game situations. All these variables are signed on the final interpretation.

The interpretation of results in intensive zones has a severe limit. In Table 1, we have provided an overview of SF intensive zones, and we are convinced that there are several other possibilities for interpretation in the world. This diversity makes it impossible to compare individual team sports simply with each other. Perhaps the question is how the results should be interpreted. There is a variant of creating a methodological recommendation that team sports are evaluated primarily by individual percentages of SF_{max}, from which it would then be easy to calculate any ranges of intensive SF zones. This would leave the option of choosing the primary interpretation of the results and provide other authors with the possibility of comparison. We tried a similar comparison in Graph 3, where we identified the limit of 85% SF_{max} as the common denominator. It turns out that the most similar load for ball hockey players is for floorball players.



Graph 3. Comparison with Other Team Sports. Values are given as a percentage of the time spent in a particular SF zone.

The fact that significantly affects SF is the time spent on the field. The longer the player was under load, the closer he got to his maximum. The average substitution time is one minute, and the net game time spent in one substitution is about 50 seconds. However, in the match, it happened to us that the player was not at all on this average. It was either due to a short rotation or an extended rotation due to the impossibility of substitution. Differences in the number of substitutions for individual players per match are also included in the final result. The players from the third line are less deployed in particular formations, and thus their time between individual rotations is many times higher. Especially in moments when there is systematic exclusion, both on the opponent's side or the side of the monitored team. Such a player has undergone a maximum of four rotations per third, as opposed to the busier player, who regularly manages six or more rotations per one period. We watched the most prolonged delay between the two substitutions for the TP9 player with a length of 12:45 minutes.

Net game time is essential to clarify the specific load of individual players in specific game situations (balanced and non-balanced games). As expected, the time spent in the higher SF zones increased, as the evaluation did not include rest or interruption in the game. As part of the net game time evaluation, we evaluated the particularly net game time in a five-on-five game, a short-handed play, and a power play. In these situations, we have even shared the burden of attackers and defenders. In unbalanced situations, we no longer distinguish between short-handed play and the type of power play. We would need much more data for this, so we are not sure whether the results are sufficiently quantified, and therefore we must self-critically evaluate that better results would be achieved with more extensive measurements.

On the other hand, these data are instead a tertiary result in the whole spectrum of results. Interestingly, the power play was played from 20.8% of the net game time, and the short-handed play was played from 12.3%. The remaining 66.9% of the game time was five against five.

SF at the beginning of rotation is a theoretical indicator of an individual's ability to recover from exercise (Ostojic et al., 2010). After the rotation, the players were at the level of 72% SF_{max}, similar to the SF caused by emotional action at the beginning of the periods (65% SF_{max}). TP7, who was at less than 80% SF_{max} at the beginning of the rotation, has the highest values. It must be added that this player was the most involved in the game.

SF at the end of the rotation reaches significantly higher values, which can be said to be that players reach the level of less than 90% SF_{max}. We had a value of 100% SF_{max} once for the TP6 player within the results. This player has values of less than 95% SF_{max}. TP7 and TP5 are approaching this individual. The TP1 player (defender) is significantly low, reaching values just below 85% SF_{max}.

Some players reach the heart rate peak at 100% SF_{max} (four occurrences). However, the players reached an average of less than 92% SF_{max}. The lowest values were again recorded for the TP1 defender (87.43% SF_{max}). The exciting thing about the culmination of SF is that it occurs after the end of the rotation in most cases. We did not observe this phenomenon in 32 cases (7.86% of all cases), which culminated during the rotation, and in 70 cases (17.20% of all cases), the culmination was at the end of the rotation.

Previously, the ČMSHb methodology took over the ratio of load to rest from the ice hockey results (Komárek, 2019, telephone interview). The ratio of 1: 5 was most often reported (Bukač & Dovalil, 1990). Today, the association's methodology does not specify load conditions (Komárek, 2020). Our study, evaluating 407 rotations, concluded that the ratio of the entire rotation to rest is 1: 2.9. We think this is the most appropriate indicator of the load-to-rest ratio, as it is limited by the player's entry and exit into the game process. This ratio is calculated with the inclusion of 00:00 minutes in the average rest (end of the third). Without this, the ratio in the results for each value will increase by 0.1, which we do not consider a distorting indicator. Regarding the ratio, it should be noted that we have calculated all the ratios in all rotations for our own needs, and as an interesting fact, we state the lowest ratio of 1: 0.3 and, conversely, the highest at 1: 66.9. These two extremes show how variable ball hockey is.

We did not include overtime data in the standard results. This happened twice; once we ran out of camera battery and therefore could not be evaluated. In the second case, one player played one substitution in overtime. Therefore, we will add that overtime is played three against three. One case of not recording one-third also did not get into the results because the receiver was released to the player during a personal duel in the first rotation of the second third. He corrected his commitment only during the break between the thirds, where he noticed this release.

One player experienced an unexplained extreme one-time decrease in SF during the research. We observed this decrease eight times, and therefore we do not take it as an artifact that distorts the results compared to the total number of recorded heartbeats.min^{-1}.

CONCLUSION

Ball hockey load manifested by heart rate is most to floorball load. Players move above the level of 85% SF_{max} in 26.2% of the time, of which 3.4% of the time in the zone above 95% SF_{max}. In the pure-play, players are above 85% SF_{max} in 44.7% of the time, of which 5.3% are in the zone above 95% SF_{max}. The psychoemotional load at the moment of the beginning of the third increases the SF to the level of 65.46% SF_{max}. At the start of the new substitution, SF players have 71.88% SF_{max}. At the end of the rotation, SFs have 89.33% SF_{max}. Load intermittency causes a delay in the SF peak, which occurs on average 11 seconds after the run and increases by an average of 5.96 bpm per minute to 91.89% SF_{max}.

The ball hockey substitution is played for an average of 62 seconds, of which the average playing time is an average of 50 seconds. This is followed by a rest of 3:01 minutes on average. The ratio between rotation and rest is 1: 2.9.

The research limit is the relatively small number of measured matches, which would help to better explain the load in various unbalanced situations, such as overpowering and weakening. It would also be obvious to increase defenders' ratio to attackers and include goalkeepers in the monitoring.

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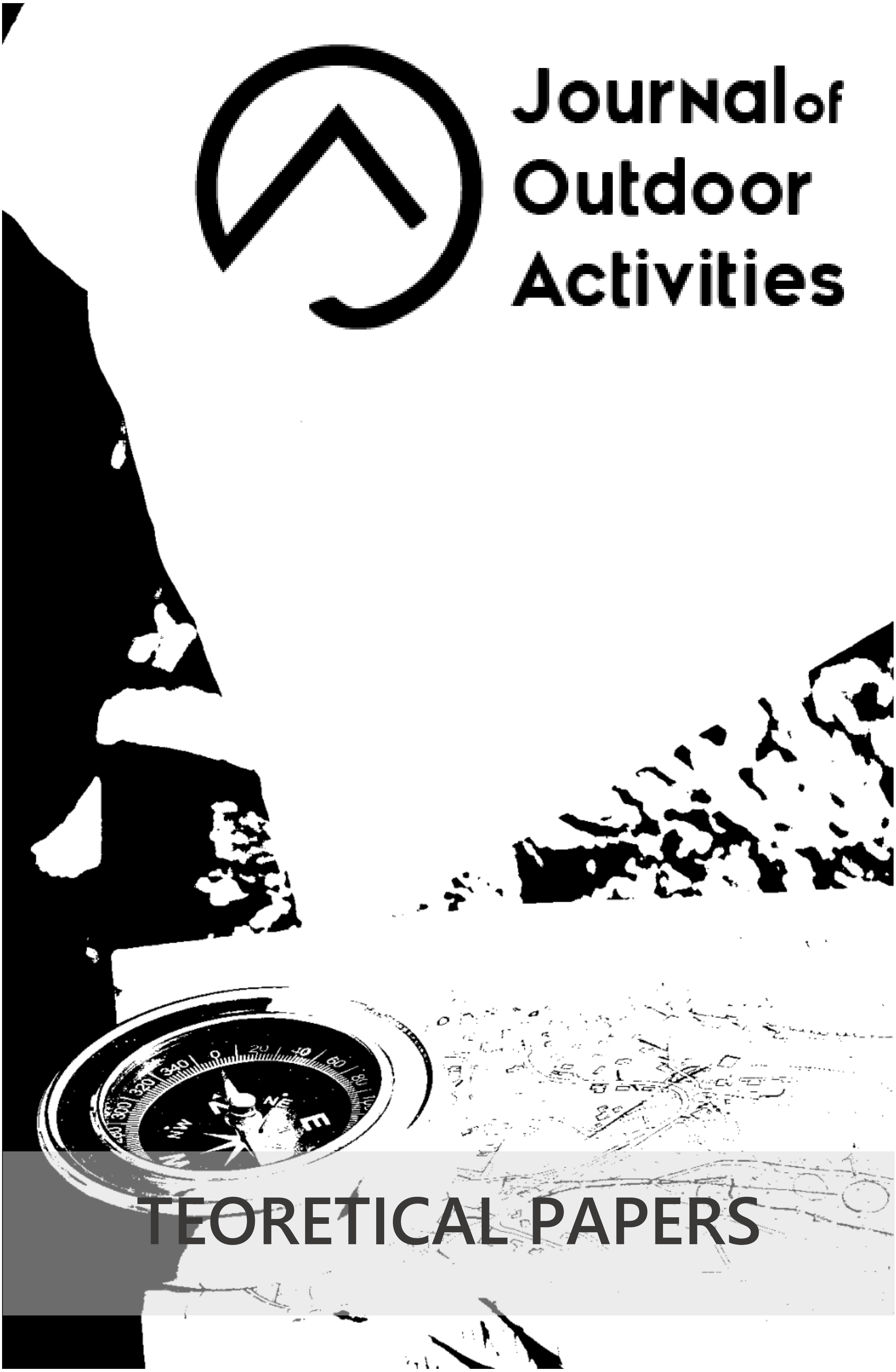

TEORETICAL PAPERS

Orienteering in Lockdown Condition – Tools for Training Support

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ABSTRACT
Introduction: The current times are influenced globally by the application of anti-epidemic measures to combat COVID-19. These are applied to varying degrees or an extent, but the common denominator is the frequent impossibility of running mass sports events. Sport or physical activities are thus suppressed, which is reflected in a decrease in physical activity and, therefore the condition of the population (Eurostat, 2020). Furthermore, the adverse effects of hypokinesis on an individual's health are documented in detail in the literature and generally accepted as a fact (Araújo, & Mesquita 2019; Vedukhina, Lobygina, & Sharapova, 2016).
Aim: This study aims to summarize and compare available applications that allow individuals to undergo physical activity based on the content of the sports industry, which is orienteering, while respecting the limitations of pandemic restrictions aimed mainly at preventing the gathering of more people.
Methods and Materials: Theoretical methods were used, especially the descriptive and comparative methods. Many foreign sources and manuals related to individual applications were analyzed. User evaluation of these applications on web platforms was also taken into account. The described applications were assessed within an expert panel who assessed and evaluated the individual platforms within a uniform methodology. Pairwise comparison was used as a research technique.
Results: The result is a summarizing and comparative overview of individual applications, enabling the implementation of an activity based on the principle of orienteering through digital technologies and respecting the limits that come with anti-pandemic restrictions, especially at the level of potential contact in gathering multiple people. The iOrienteering platform is evaluated as the most practical application; the MOBO application is the opposite end of the assessment scale.
Conclusion: The iOrienteering and O-range applications were evaluated as the most beneficial according to the specified criteria. The applications under consideration are suitable for use under the current movement-restricting regime resulting from pandemic restrictions.
Key words: digital technology, lockdown, mobile applications, orienteering

SOUHRN
Úvod: Současná doba je celosvětově ovlivněna aplikací protiepidemických opatření v rámci boje proti onemocnění COVID-19. Tato jsou uplatňována v různé míře či rozsahu, společným jmenovatelem je však častá nemožnost provozování hromadných sportovních akcí. Sport či pohybové aktivity jsou tímto utlumeny, což se v důsledku projevuje poklesem fyzické aktivity, a tedy i kondice obyvatel (Eurostat, 2020). Negativní dopady hypokineze na zdravotní stav jedince je v odborné literatuře podrobně zdokumentován a jako fakt všeobecně přijímán (Araújo, & Mesquita 2019; Vedukhina, Lobygina, & Sharapova, 2016).
Cíl: Cílem této studie je sumarizovat a komparovat dostupné aplikace, které umožňují absolvovat jedinci pohybovou aktivitu, vycházející svým obsahem ze sportovního odvětví, kterým je orientační běh a při tom dodržet omezení vyplývající z restrikcí v rámci pandemického stavu mířící zejména k zamezení shromažďování více osob.
Metody: Využity byly metody teoretické, zejména metoda deskriptivní a komparativní. Analyzovány byly namnoze zahraniční zdroje a manuály vážící se k jednotlivým aplikacím. V potaz též bylo bráno uživatelské hodnocení těchto aplikací na webových platformách. Popisované aplikace byly posouzeny v rámci panelu expertů, kteří jednotlivé platformy posuzovali a hodnotili v rámci jednotné metodiky. jako výzkumná technik bylo využito párové srovnávání
Výsledky: Výsledkem je sumarizující a komparativní přehled jednotlivých aplikací, umožňující realizovat aktivitu vycházející z principu orientačního sportu prostřednictvím digitálních technologií a respektující limity, která sebou přináší protipandemická omezení, a to zejména v rovině potenciálního kontaktu v rámci shromažďování vícero osob. Jako nejpřínosnější aplikace je vyhodnocena platforma iOrienteering, na opačném konci posuzovací škály je aplikace MOBO.
Závěr: Jako nejpřínosnější dle zadaných kritérií byly vyhodnoceny aplikace iOrienteering a O-range. Posuzované aplikace jsou vhodné pro použití za současného, pohyb omezujícího režimu, který je důsledkem protipandemických opatření.
Klíčová slova: digitální technologie, lockdown, mobilní aplikace, orientační běh,

INTRODUCTION

The beginning of 2021 is marked by a worldwide fight against the pandemic spread of COVID-19. Among the measures applied by individual governments is a greater or lesser form of limiting the risk gathering of persons and restricting their mobility, whether within a municipality, region, state, or country. Area quarantine measures vary from an absolute "lockdown" to the definition of a perimeter in which an individual or several persons are allowed to move freely at once. For example, in the spring of 2020, Italy restricted population movement for one month, Israel at the beginning of fall 2020 a perimeter of 500 meters for unrestricted movement, and in February 2021, the German population was allowed to move within 15 km of the place of residence. The Czech government adopted a similar plan to restrict movement within districts and the cadaster of residence. It also limits the number of people who can be in contact at one time. This is also one of the main obstacles to organizing mass sports events or even practice.

In our paper, we want to focus on the problem of how to organize and perform physical activity, explicitly orienteering in these limiting conditions, because organizing a mass event to which the organization of a race or practice in orienteering is not possible for the above reasons.

Although orienteering is an individual sport in a natural environment, people's contact during the racing or training activity itself is minimal, but the logistics of organizing a practice or race, to a large extent, require contact. The race or practice usually has a designated meeting place, where the participants present themselves and read the chips after the race with the recorded passage through the individual checkpoints, the start, and place with issuing maps is again a risky location with the start and place with issuing maps the potential for unwanted contact. In addition, tens to hundreds of participants usually attend local events or practices such as winter leagues, a regular race at the regional level of thousands, not to mention international multi-day races, where the number of participants reaches several thousand in all age categories.

Through digital technologies and suitable applications, it is possible to organize an orientation race in a "remote form", while individual solutions use a different approach and methodology. Our work focuses on capturing these differences, comparing and summarizing the devices used in individual applications.

MATERIAL AND METHODS

To obtain individual applications, we studied the web presentations of providers, and according to the degree of relevance to the goal of our work, we selected five applications, which we tested in practice through an expert panel. The criteria according to which the products were evaluated were as follows:

- availability (commercial / non-commercial)
- installation (easy / challenging)
- system requirements (including iOS / Android support)
- user interface (user friendly / more complex control)
- practical applicability
- data connection requirements
- versatility (possibility of creating more types of trainings – “scorelauf” / one-man relay / etc.)

The pairwise comparison method was used to determine the order (Havel, & Hnízdil, 2008). In the dichotomous classification using the eight above criteria, members of the expert panel compared five applications. We then arranged the data obtained from all members into a matrix *f*, whereby the used method, the value f_{ij} (i = row, j = column), represented the frequency with which the given application was evaluated better. Furthermore, within the matrix *p*, the values were converted to relative frequencies according to $p = \frac{f_{ij}}{n}$. Subsequently, the probabilities of p_{ij} were converted to z - *points* using the critical values of the normalized normal distribution function, and a matrix z was created. Finally, the arithmetic means of the column values were corrected by adding the highest negative value to eliminate negative numbers. The highest value thus indicates the best-rated application.

EXPERT PANEL

The expert panel was composed of nine experts – coaches and active athletes in orienteering from the following sports clubs: OK Jiskra Nový Bor (2) Slavia Liberec Orienteering (1) OOB TJ Turnov (2) SK Haná Orienteering (1) KOB Kamenický Šenov (2) KOB Děčín (1). Three experts hold a coaching license in orienteering, two are members of the national team of the Czech Republic, and another three have a judge's license for competitions in orienteering. Everyone was provided with data for the installation of individual applications and was asked to test them in practice within one month.

In addition to filling in the dichotomous matrix for comparing applications according to the specified criteria, experts were asked for written comments and opinions on the individual systems tested.

RESULTS

In our research, we assessed the following selected applications:

- iOrienteering
- MOBO
- UsynligO
- GPS orienteering
- O-range

Within the overview, we present brief characteristics of individual applications:

iOrienteering (https://www.iorienteering.com/)

Author R. Patton's application, available from https://www.iorienteering.com, works on the principle of placing a physical checkpoint in the terrain in the form of a QR code, which the competitor scans to his or her mobile phone via an installed application (available for free for iOS and Android). The system makes it possible to measure the time of the race/training and check whether the rules have been followed (fixed or free order of checks). The competitor may not have access to the data connection during it. The organizer first registers in the system and then has the opportunity to prepare the track. The system itself will then generate the necessary QR codes. The track builder prints them out and distributes them to the terrain. The competitor with the mobile phone with the application installed will run the whole course; he or she only scans the placed codes at the checkpoints. An internet connection is only required to download the application and, after completion, to upload the results (Hnízdil, Vojtíková, & Vařeková, 2020).

Athlete's procedure:

1) Download the installation and log in to the iOrienteering application on the mobile phone (data connection required), move to the starting position
2) Scanning of the QR code on the map or a separate sheet for loading a specific orienteering race (already fully offline)
3) Scanning the start QR code and the actual start
4) Gradual achievement of individual checkpoints (according to the assignment - free or fixed order of checks) and self-service scanning of the QR code at each checkpoint
5) Scanning the target QR code after reaching the goal of the race
6) Upload results and view them on iorienteering.com (data connected required)

(Hnízdil, & Heidler, 2020)

MOBO (https://mobo.osport.ee)

The author of this application, Estonian developer Tarmo Klaar, states on his website: "MOBO is a modern way of training orienteering. For orienteering runners, the smartphone is a "3-in-1" device with a map, compass, and a device for recording the inspection passage, all in one package. Maps in a mobile phone are standard maps for orienteering, and therefore basic skills of terrain orientation and map reading are necessary to manage the track successfully. The built-in compass shown on the phone display is used for orientation. In addition, there are special marks with QR codes at the checkpoints. Information about passing checkpoints by scanning the QR code to the smartphone is sent to a server where user statistics can be seen. The MOBO application is developed for local areas of fixed checkpoints, but with the help of this platform, an outdoor orientation event can be organized for anyone and anywhere. The first MOBO complex was opened on 1 January 2012 in the Estonian city of Keila" (MOBO, 2020).

Athlete's procedure:

1) Install the application on the phone. It is free for Android, iPhone/iPad, Windows Phone, and Nokia (Symbian).
2) Select the name of the track/map and wait for the map to download to the phone. Then, use the map and the built-in compass shown on display to search for checkpoint/s.
3) To stamp the checkpoint - select "Stamp" from the application menu (or press the [Photo] button) and take a photo of the QR code. The successful stamp of the checkpoint will be sent to the statistics server. After completing the track, the feedback can be provided on the application's information website.

UsynligO (https://usynligo.no)

The application's name by the author Trond Benum from Norway can be translated as "invisible orienteering". Unlike the previous systems mentioned above, it is based on the absence of a physical marking of the checkpoint in the terrain. This is replaced by a virtual and mobile phone application via GPS, and then an audible signal informs the athlete if he or she is in the correct position in the terrain. The distance and direction to the checkpoint can also be tracked in the help. The application also includes a compass and the ability to display a map on a mobile phone screen. However, unlike the previous application, a permanent data connection is required throughout the race/training (UsynligO, 2020). Another limit maybe the quality of the GPS signal.

Athlete's procedure:

1) Install the application on the phone. It is free for devices: Android, iPhone from their online stores
2) It is possible to log in to the application using one of three options: Google, UsynligO, or Anonymous to create a user account. In the Anonymous variant, it is not possible to publish the results in the results list.
3) Select the name of the track/map and wait for the map to download to the phone. The use of the map and the integrated compass are shown on display. It is possible to visit the "error radius" to consider possible GPS inaccuracy when tracing the inspection.
4) Finding the correct control is indicated by an acoustic signal. With a different signal, the application also announces the achievement of incorrect checkpoints (other lines, checkpoints in the wrong order).
5) After completing the activity, it is possible to send the results to the server for comparison with other athletes.

GPS Orienteering (hhtp://hippsomapp.se)

The essence, i.e., a virtual checkpoint without physically placing them in the terrain, is identical to the previous application. In contrast, it offers more advanced features. This is also related to the fact that in the full version, which is a necessity for builders/organizers, it is paid (approx. CZK 100). The athletes will be satisfied with the lite version of GPS Orienteering Run, which is free. Tracks with a map are uploaded to the application from the web interface, where they are protected by a code and password, unlike the UsynligO application, where they are public. GPS will record the athlete's position, and when he or she runs to the checkpoint, the checkpoint responds with an acoustic signal. After running to the finish line, all procedures, split times can be seen, and after uploading the data, it is possible to compare individual athletes. The application is intended only for Android devices (Google Play) and is compatible with the FOOD application (GPS orienteering, 2020).

The athlete's procedure is similar to the previous application.

O-range (https://www.storler.no/orange)

The principle of virtual checkpoints, i.e., the ability to prepare training without a physical visit of the terrain, is the essential feature of this application. Unlike the previous two, it is not installed in a mobile phone, but Garmin watches, in virtually all models with GPS and the ability to upload third-party applications. The current list of compatible devices includes 50 models, including the popular Fenix, Forerunner, and Vivoactive series. The application of the Norwegian developer Atle Pedersen is free; of course, it is possible to create own tracks and training and then offer them to the public in the "Public courses" section. The implementation of the race or training is similar to previous applications; instead of a mobile phone, a Garmin watch (O-RANGE, 2021) informs us about the achievement of the correct checkpoint with an acoustic signal.

Athlete's procedure:

1) Install the application on a Garmin device
2) Creating an account on the O-Range website
3) Pair the Garmin device with an account
4) Download tracks to Garmin device - Livelox or O-Track platforms can be used as an equivalent
5) Download and print the map
6) Start the activity

Table 1 lists all assessed applications in the order as they were assessed according to individual criteria by individual members of the expert panel (see methodology).

Table 1 *The resulting corrected values of the column diameters of the matrix z for individual applications:*

Application	Points
iOrienteering	1.73
O-Range	1.16
UsynligO	0.95
GPS orienteering	0.12
MOBO	0

Note: The highest value indicates the best-rated app

DISCUSSION

Based on the overview we have created, we can divide the available applications into two categories despite several common aspects and functions. On the one hand, these are applications whose essence is the physical placement of marking of control stations in the terrain (MOBO, iOrienteering). On the other hand, applications that can be marked as virtual, i.e., the builder (organizer), are not required to physically attend the terrain (GPS orienteering, UsynligO, O -Range). However, this concept of structuring is sustainable only on a theoretical level. It can be used for fundamental division, but from the practice of builders of orientation training and competitions, it is known that each builder, although he/she has the opportunity to "build" a checkpoint virtually, in practice will still use the opportunity to visit the place in the terrain. The reason is the effort for proper race/training, i.e., the effort is to check that the current situation in the terrain corresponds to the state of the map data. The higher the age of the map, the more urgent it is to physically visit the race/training area and correct the location of the checkpoints compared to the concept prepared at home.

Another possible factor according to which it is possible to divide the available applications is a GPS. This system is necessary for the operation of GPS orienteering, UsynligO, O-Range applications. It can be used, but iOrienteering does not need to work. The use of the GPS is also associated with its accuracy in specific conditions and terrains. To refine the positioning data, in addition to the standard considered to be the American GPS, the technologies allow the use of the European Galileo system or the Russian GLONASS. This is often linked to the type and quality of the mobile phone or similar device used and unrelated to the applications. However, the applications offer to some extent the inaccuracy of positioning to be corrected within the possibility of setting a specific radius in which the system still considers the achievement of the checkpoint to be successful (e.g., 15m). This should be taken into account in elevated terrains; use in urban areas is, in our opinion and experience, burdened by a higher degree of unreliability.

One of the aspects that may have seemingly influenced the evaluation of the experts within the expert panel is the question of the builder's/organizer's point of view and the competitor's/training person's point of view. In orienteering, however, both of these roles are combined, and it can be stated that the builder in his work tries to "slide" into the feelings of the competitor and the competitor in tactics and mind of the builder, which affects and determines the track. All members of the panel we contacted are active competitors, and at the same time, half of them are also builders of successful national and international races and events. The second half of the experts also has experience with the construction of training and local races. Therefore, we can state that with the expert choice of the members of the expert panel, we took into account the view of both the builder and the competitor on the submitted applications.

Discussion on the final evaluation of individual applications within the expert panel:

Representatives of both categories defined above appeared in the first two evaluation places, i.e., the highest-rated iOrienteering application using the principle of physically located checkpoints in the terrain and the O-range application based on the second on virtual checkpoints achieved. This application is placed at the top in the "category" of virtual checkpoints, and it is possible that because it is not the only one tied to the use of a mobile phone in the activity. It is installed in a watch that athletes commonly use in orienteering races and training. This may consider some of the discomfort associated with using a mobile phone while running and moving in the terrapin. There is always a risk of falling and possible damage to this mobile technology.

For the best-rated application (iOrinteering), which is based on the principle of scanning QR codes when passing through the checkpoint, the judges especially appreciated the user-friendly environment within the application and web interface for creating both QR codes and preparation and implementation during races or training. On the other hand, for the MOBO application, which is very similar in principle, the reason for its negative evaluation, which in the sum meant the last place, was probably the fact that to create the track and generate QR codes, it is necessary to contact the creator of the application and request his or her consent.

In our opinion, both iOrienteering and MOBO applications are suitable not only for one-off training events but especially for permanent use in the so-called fixed control areas. The added value of the MOBO application is the possibility to use contactless NFC technology when marking the passage through the checkpoint. This eliminates a certain discomfort when conventional QR code scanning, affecting the quality of the integrated camera and the lighting conditions or QR code print quality. Furthermore, if we use the lamination of these codes, the reflection of light can make it difficult to read them correctly. Our experience shows that the best distance between the QR code and the phone to "stamp" the control is about 20-50 cm, but it depends on what program is used to read QR codes (applies to the MOBO application) and on external conditions.

A prerequisite for the correct use of the compass in applications that allow it is its calibration, optimally after switching on the phone. In addition, the sensors may require regular recalibration. To calibrate, it is necessary to follow the instructions, usually holding the phone in front and moving it in the figure-eight symbol.

CONCLUSION

Ideal application from the competitor's point of view: Physically checkpoints are located in the field, and passage through them can be realized through wireless technology, optimally placed in a wristwatch.

Ideal from the builder's / organizer's point of view: There are no physically located checkpoints in the field, the correct passage is recorded via a quality (accuracy 5m) GPS signal, and immediately after the finish, the race/training is uploaded to the server, where compliance with the rules and competitor/trainer is automatically evaluated. This is included in the relevant result list to compare the results, including individual split times. (Hnízdil, Vojtíková, & Vařeková, 2020).

These applications are suitable for organizing orienteering activities in conditions affected by restrictions on free movement or the possibility of gathering more people.

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