

THE LEVEL OF INFLUENCE OF ORGANISED PHYSICAL ACTIVITY ON MEETING THE HEALTHY CRITERION OF 10,000 STEPS DAILY: APPLICATION OF REGRESSION AND FORMAL CONCEPT ANALYSIS

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BACKGROUND: Organised physical activity (PA) belongs among factors significantly influencing the amount of realised PA.

OBJECTIVE: The objective of our study is to find out with the use of classical statistical methods and formal concept analysis (FCA) how organised PA influences the meeting of the healthy criterion of 10,000 steps per day on a particular day. What daily frequency of participation in organised PA is beneficial for meeting this healthy criterion?

METHODS: Men (1,749) and women (2,293) aged 12 to 84 years participated in the research. Their weekly PA was monitored using the pedometer Yamax Digi-walker SW700. We used logistic regression and FCA for data analysis.

RESULTS: Organised PA markedly increases the number of realised steps per sport/exercise day compared to non participation in organised PA. Logistic regression revealed that participation in organised PA 1–2 times per week raises, by more than four times, the chance to meet the above mentioned healthy criterion. Men have got about a 30% higher chance for meeting 10,000 steps per day than women. People with normal weight have got a greater chance of meeting this criterion. On the other hand, obese people have difficulty in meeting the criterion. According to the FCA, women who participate in organised PA more than 4 times per week are more likely to meet this healthy criterion (88% compared to 66%); men are more likely to meet the criterion if they participate in organised PA 3 times and more per week (91% compared to 70%).

CONCLUSIONS: For better understanding of the results we recommend using a combination of statistical and other assessment methods, for instance FCA. Participation in organised PA at least once a week positively influences the meeting of the above described healthy criterion.

Keywords: Yamax Pedometer, logistic regression, age, obesity, fuzzy logic.

INTRODUCTION

In our contemporary technologically modernised world there is less and less room for PA as people devote themselves to computers, television and other passive entertainment. Very often researchers use the criterion of 10,000 for the evaluation of PA with the use of pedometers, which is a well known and popular criterion for health promotion. People who perform 10,000 steps per day are very likely to meet the criterion of the American College of Sport Medicine (Le Masurier, Sidman, & Corbin, 2003). This also supports the statement that reaching 10 thousand daily steps is the amount of PA bringing health benefits (Bernard, Pak, Choi J., & Choi E., 2007; Tudor-Locke & Bassett, 2004). Physical activity is, during a typical week, influenced by one's working routine, family duties and other obligations. That is why it is necessary to study relationships also regarding particular days of the week. Participation in organised PA belongs among crucial factors positively influencing the amount of PA (Van Mechelen, Twisk,

Post, Snel, & Kemper, 2000). Poor participation in sport (organised PA) in childhood and adolescence is connected with the higher occurrence of physical inactivity in adulthood and, on the other hand, sport participation during adolescence has got a positive effect on health in adulthood thanks to the reduction of the probability of adult inactivity (Tammelin, Näyhä, Laitinen, Rintamäki, & Järvelin, 2003). Organized PA can markedly raise the amount of PA realised in a given day (Tudor-Locke et al., 2004). Apart from organised PA, the amount of realised PA is influenced by other factors, such as age, gender, obesity, socio-economic status, educational attainment but also weather and the season (Frömel, Mitáš, & Kerr, 2009; Pelclová, Vašíčková, Frömel, & Djordjevic, 2010; Pratt, Macera, & Blanton, 1999; Sallis, Prochaska, & Taylor, 2000; Sigmund et al., 2008; Suchomel, Sigmundová, & Frömel, 2008).

Studying regularities in physical behaviour using statistical methods cannot always be reliable. In logistic regression analysis, model evaluation is represented by the Nagelkerke R^2 coefficient, but many published arti-

cles do not present a measure of the pseudo-variance explained (Pampel, 2000). In these cases we recommend using the Formal Concept Analysis (FCA) method that is based on searching for concepts (clusters) in a data table. Concepts then represent common characteristics of the object group. Its strength is not only in searching for concepts but also in the creation of structures of concepts (lattices) and that findings can be specified or generalised.

The aim of this study is that, with the use of a combination of classical statistical methods and formal concept analysis, we can find out to what extent organised physical activity influences the meeting of the healthy criterion of 10 thousand steps per day on a certain day. What weekly frequency of participation in organised PA creates the preconditions for meeting this healthy criterion? What other factors influence meeting the healthy criterion?

METHODOLOGY

The current study was undertaken in the Czech Republic after approval by the Institutional Research Ethics Committee at Palacký University. Participation was voluntary and participants received no incentives and could withdraw from the study if they wished. Participants were provided with information about the aims, objectives and methods of the survey before the start of the monitoring of their physical activity. Data were anonymous and confidential and data protection was observed at all times. Each participant (or legal representative) signed an informed consent form for inclusion in the study.

The survey and monitoring of physical activity were undertaken during the years 2008–2010 in the Czech Republic. We used Microsoft Excel to randomly select addresses. Trained research coordinators visited each selected household, and family members were informed about the study's aims/objectives and asked if they wished to participate in the study. If in agreement, each participant signed an informed consent form, completed the questionnaire and participated in the physical activity monitoring.

Men (1,749) and women (2,293) aged 12 to 84 years participated in the research. Their weekly PA was monitored using the pedometer Yamax Digi-walker SW700. We eliminated respondents with implausible or missing data or because they wore the pedometer for a short period of time during the day (less than 10 hours). We analysed data from 2,157 women (with a mean age of 29.87 ± 13.03 years) and from 1,648 men (with a mean age of 29.73 ± 12.37 years).

For data evaluation we used logistic regression and basic statistical methods. Regression analysis of the

meeting of the healthy criterion of 10,000 steps daily (0 = does not meet the criterion) was calculated for each day of the week and also in total for the whole week. Independent variables entering into regression were organised PA (physical activity led by a teacher or trainer), gender (males, females), groups according to BMI (underweight, normal weight, overweight, obese), and age (age categories 12–18, 19–25, 26–39, 40–54, 55 and more years). Age categories were created to respect the proportionality in the data file. The category of 12–18 years was created with regard to age differences in children and youth, e.g. the assessment of BMI is different for the adolescent and adult population (CDC, 2009). Logistic regression was calculated using the Forward Stepwise method (Likelihood ratio).

A further method which was used is called Formal Concept Analysis (from here onward in this text to be referred to as FCA). Formal concept analysis uses terms like formal context, formal concept and formal concept lattice (Ganter & Wille, 1999).

From the point of view of these terms, a questionnaire can be understood as providing a formal context where respondents create a group of objects, questionnaire questions create a group of attributes and respondent's answers to each question creates binary relationships. Considering that most of the answers to questions are not bivalent and it is a special type of context, it is called multivalued. With this type of context FCA cannot work. It's necessary to transform it into bivalent form. This process is called scaling.

The result of scaling is a formal context where the objects are individual respondents. In most cases we are not interested in the relations among respondents but in the group of respondents indicating some common features or attributes. The method of construction of so called "aggregated objects" works based on this fundamental thought. This method is described in detail in the study of Belohlavek, Sklenar, Zacpal, and Sigmund (2007).

The result of this adjustment is the creation of a formal fuzzy concept lattice. Here, instead of classical sets, we work with fuzzy sets and use fuzzy logic instead of classical logic. For details see the book by Belohlavek (2002) about formal fuzzy concept analysis. From this fuzzy context we calculate a fuzzy concept lattice. The problem with a fuzzy concept lattice is its size and the presence of concepts that are absolutely uninteresting. There are mostly concepts that to a certain extent do not include a single object with a degree of truth of 1. Such concepts are eliminated from the unit and we leave only the so called "crisply generated concepts" (Belohlavek, Sklenar, & Zacpal, 2005). The set of crisply generated concepts create again a lattice. This limited unit is then analysed.

RESULTS

Regardless of their participation in organised PA, men performed an average of 11,200 steps per day ($SD = 3,652$), while women performed an average of 10,612 steps per day ($SD = 3,444$). From Fig. 1 and 2 it is evident that organised PA increases the number of realised steps taken on sport/exercise days as opposed to the days with non participation in organised PA. These differences in men range between 2,750 steps on Monday up to 4,830 steps on Friday. In women the smallest differences are between the days with and without organised PA on Monday (the difference is 2,013 steps) and the biggest differences are on Sunday (3,539 steps). Regardless of a deeper knowledge of someone's weekly routine, Friday is the day with the highest number of steps both in men and women.

From TABLE 1 we can see the positive influence of organised PA on meeting the healthy criterion of

10,000 steps per day. People participating in organised PA have got a 3 times better chance of meeting this criterion. Moreover, on some days men have got a better chance of meeting this criterion as compared to women. TABLE 1 shows that obese people have only half a chance of meeting the standard of 10,000 steps per day as compared to underweight people or people with normal weight. This chance is on the decrease with age. Nevertheless, logistic regression showed, on a particular day, a low coefficient of Nagelkerke R^2 .

The method of logistic regression is, unlike the FCA method, based on analysing a formal (fuzzy) concept lattice. From the adjusted context of data about the number of steps and the frequency of participation in weekly organised PA in all respondents we create a formal fuzzy concept lattice and compare "interesting" concepts. Final sub units classify respondents according to their participation in organised PA and are displayed separately for women (Fig. 3) and for men (Fig. 4).

Fig. 1

The mean number of steps in females with regard to organised PA on certain day (steps/day)

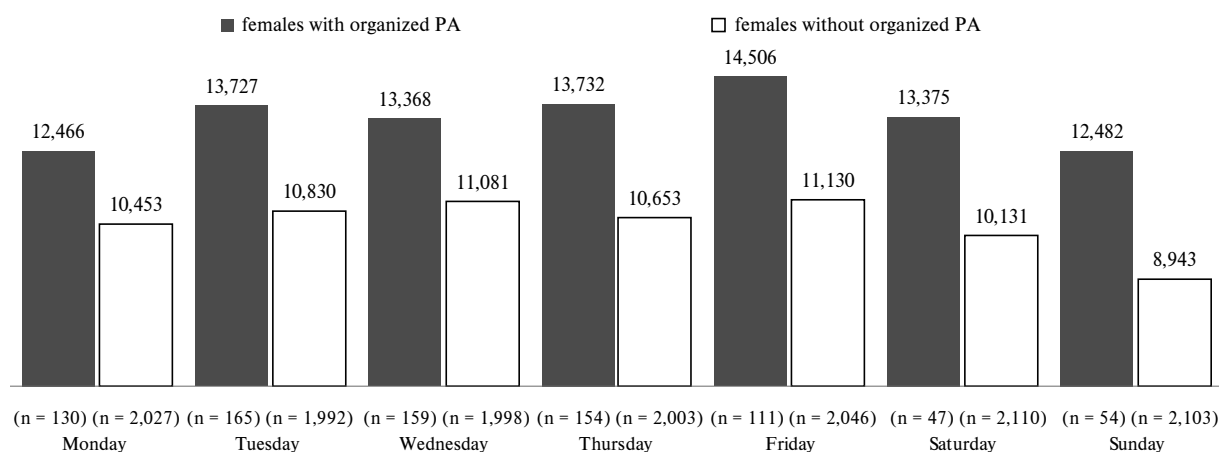
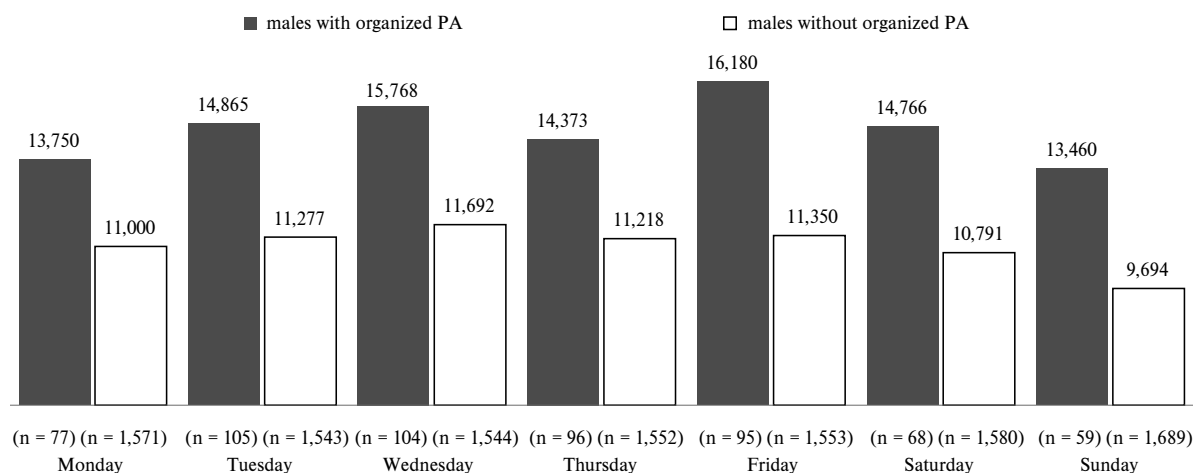


Fig. 2

Mean number of steps in males with regard to organised PA on certain day (steps/day)



Visualised values range from 0 to 1 and as a percentage express the number of respondents from a certain group who have got a given feature. In this case, as a percentage, it illustrates the results of respondents according to their participation in organised PA, who meet the healthy criterion of 10,000 steps per day.

Fig. 3 and 4 show that a considerable increase in the degree of meeting the healthy criterion of 10 thousand steps daily occurs in women participating in organised PA 4 times and more weekly (88% compared to 66%), while occurring in men participating 3 and more times per week (91% compared to 70%). An interesting fact is the decline in the number of men who participate in organised PA 6 times per week. It can be explained by the small number of respondents in this group ($n = 9$).

From Fig. 5 it is evident that also the mean number of steps per day rises with the higher frequency of participation in organised PA. This trend occurs both in men and women. Also we can see that participation in organised PA once a week is not sufficient for meeting the healthy criterion of 10 thousand steps per day.

In our sample 50% of the respondents do not participate in organised PA, 38% participate in organised PA once a week, 6% participate twice a week, 7% participate in organised PA 4 times per week and 3% of the

respondents participate in organised PA more than four times per week.

Logistic regression revealed that participation in organised PA multiplies the chance of meeting the healthy criterion compared to people who do not participate in organised PA. Men have got about a 30% greater chance of meeting the limit of 10,000 steps per day than women. Further, people with normal weight are more likely to meet this criterion than obese people. Crucial factors for the number of realised steps are also age; with aging the likelihood of meeting the criterion declines (TABLE 2).

The FCA method also revealed a decline in overweight and obesity in respondents with organised PA. Among women without participation in organised PA we discovered 20% of overweight or obese women as compared to women with participation in organised PA at least once a week where the occurrence of overweight and obesity decreased to 10%. In men without participation in organised PA we found that 34% of the respondents were overweight or obese, whereas 28% (resp. 26%) of the respondents were found to have participated in organised PA once a week (resp. twice a week). The frequency of participation in organised PA of 3–7 times a week is associated with an occurrence of overweight

TABLE 1

The influence of organised PA and other factors on meeting the healthy criterion of 10,000 steps per day

	Monday OR	Tuesday OR	Wednesday OR	Thursday OR	Friday OR	Saturday OR	Sunday OR
Organized PA							
No participation	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Participation	1.929**	2.320**	2.423**	2.352**	3.290**	3.129**	2.598**
Sex							
Women	Ref.	X	X	Ref.	X	Ref.	Ref.
Man	1.221**			1.216**		1.188*	1.323**
BMI							
Underweight	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	
Normal weight	1.019	1.366	1.307	1.132	1.659**	1.110	X
Overweight	0.789	1.244	1.105	0.926	1.394	0.975	
Obese	0.528**	0.732	0.412	0.529**	0.691	0.605*	
Age							
12–18 years		Ref.	Ref.		Ref.	Ref.	Ref.
19–25 years	X	1.219	0.788*	X	0.837*	0.802	0.763*
26–39 years		1.037	0.685**		0.745*	0.768*	0.746*
40–54 years		0.917	0.591**		0.653**	0.727*	0.698**
55 and more years		0.653*	0.510**		0.473**	0.548**	0.578**
Nagelkerke R ²	0.019	0.036	0.04	0.026	0.05	0.028	0.02

Legend: OR – odds ratio, * $p < 0.05$, ** $p < 0.01$, X – regression analysis did not include the variable into model

Fig. 3
Visualization of the probability of meeting the healthy criterion regarding the frequency of participation in organised PA - FEMALE

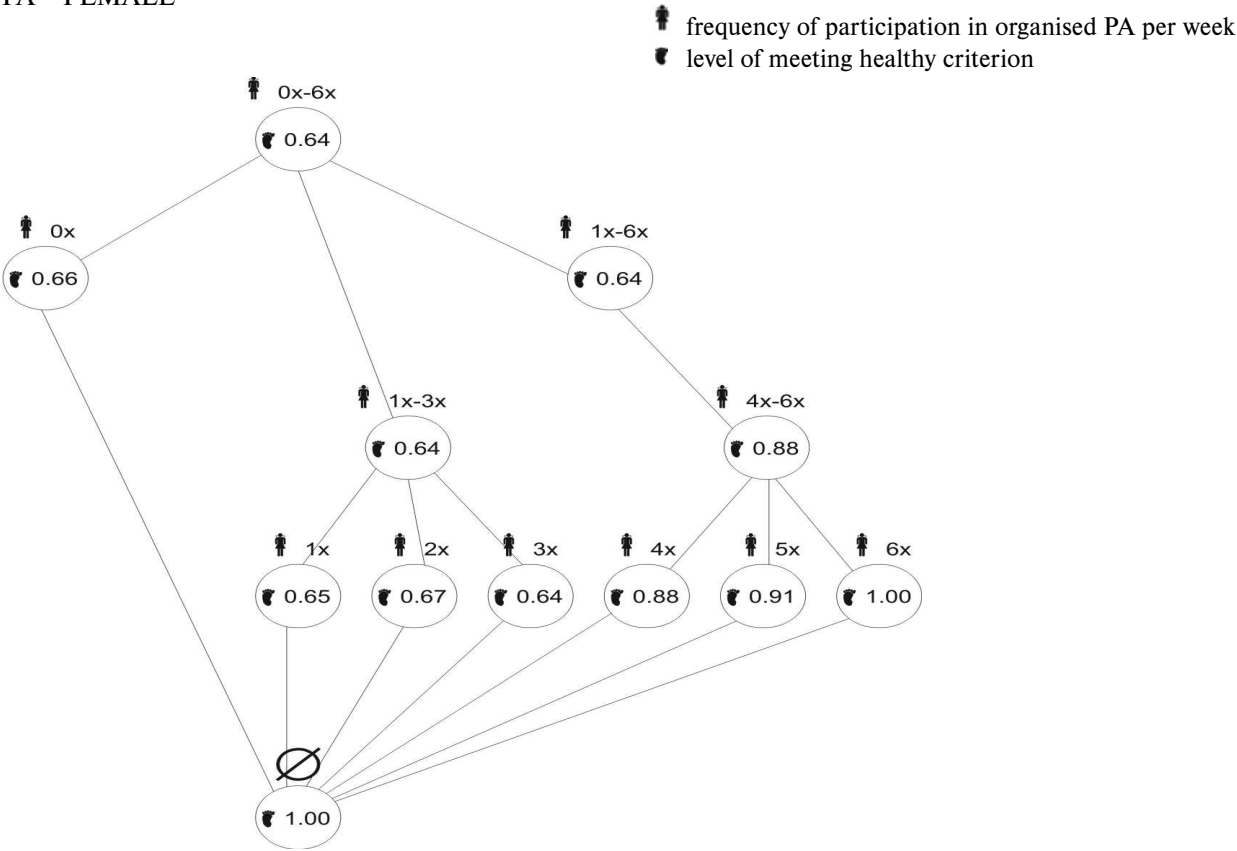


Fig. 4
Visualization of the probability of meeting healthy criterion regarding the frequency of participation in organised PA - MALE

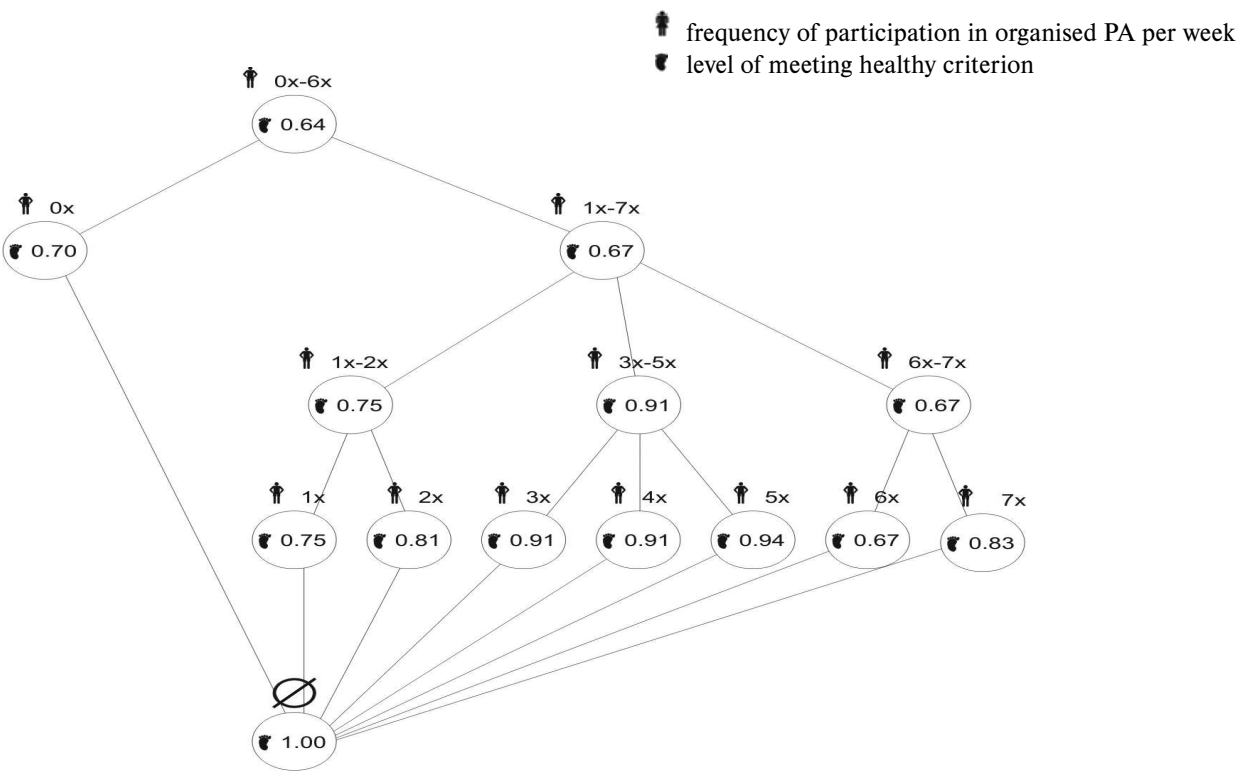
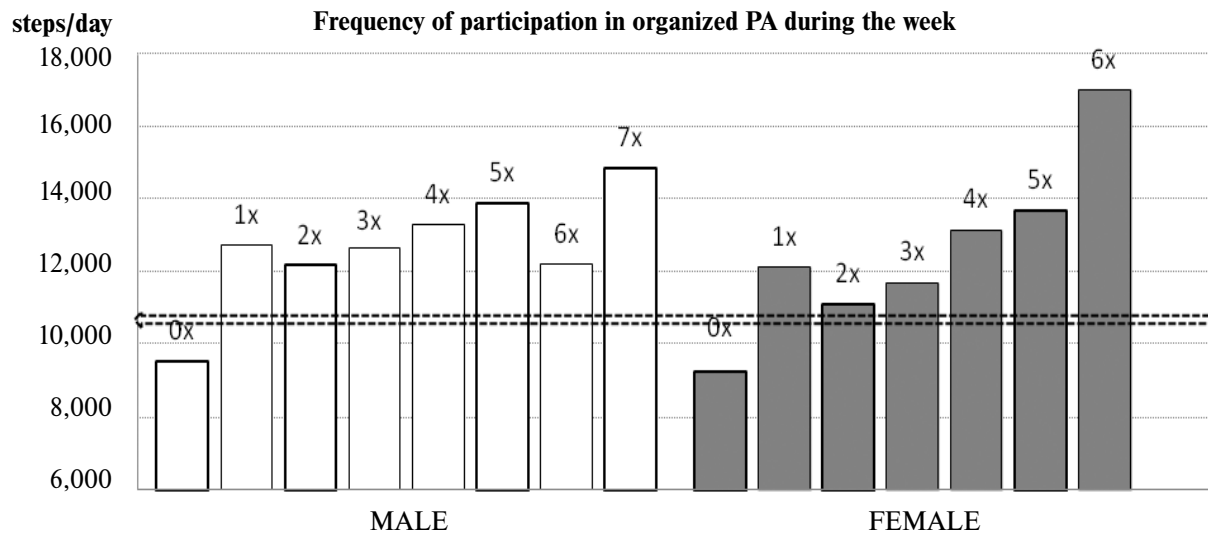


Fig. 5

Number of daily steps according to frequency of participation in organized PA during the week (0–7×)

**TABLE 2**

Influence of organised PA and other factors on meeting the healthy criterion of 10,000 steps per day

	n	% ^a	OR	CI
Organized physical activity				
No participation	1893	40.3	Ref.	
Participation 1–2times per week	1457	75.7	4.517**	3.877–5.263
Participation 3–4times per week	334	67.4	2.749**	2.136–3.539
Participation 5times and more	121	84.3	6.506**	3.939–10.746
Sex				
Women	2157	54.9	Ref.	
Man	1648	61	1.299**	1.123–1.503
BMI				
Underweight	177	53.7	Ref.	
Normal weight	2727	61.3	1.496*	1.067–2.098
Overweight	713	50.9	1.054	0.721–1.541
Obese	188	32.4	0.638	0.394–1.033
Age				
12–18 years	398	62.6	Ref.	
19–25 years	1716	62.9	0.996	0.777–1.276
26–39 years	842	56.1	0.819	0.625–1.074
40–54 years	628	47.3	0.729*	0.544–0.979
55 and more years	221	42.08	0.662*	0.452–0.971

Legend: %^a – participants, who meet the criterion; OR – odds ratio; CI – confidence interval; *p < 0.05; **p < 0.01; Nagelkerke R² = 0.19

and obesity ranging from 6 to 20%. Furthermore, according to FCA, we found out that the greatest representation of respondents who are the most likely to

meet the healthy criterion of 10,000 steps daily is in the age category of 19–25 years regardless of gender and frequency of participation in organised PA.

DISCUSSION

The main goal of this study is, by means of using a combination of classical statistical methods and formal concept analysis, to find out to what extent organised PA influences the meeting of the healthy criterion of 10 thousand steps per day on a particular day. What frequency of participation in organised PA is beneficial for meeting the healthy criterion? What other factors influence meeting the healthy criterion?

Data are quite often adjusted to the applied statistical method and it can partially devalue their predictive value. Regression analysis often shows the low reliability of a model that is represented by a Nagelkerke R^2 coefficient. Moreover, often this coefficient is not mentioned in the results section of studies. Results with a low Nagelkerke coefficient are then very difficult to interpret because the model encompasses only a small part of the observed phenomenon. The FCA method is based on a relationship of equivalence, which is why we can speak of the probability of a phenomenon's occurrence. A calculated value range from 0 to 1 and expressed as a percentage gives us the number of respondents from a certain group who have a certain attribute. Even FCA, because of its complicated methodology can appear to be limited; in easier models (units) it gives a clear summary about the extent of reaching an observed phenomenon regarding chosen categories. For better understanding of such results it is required that we combine both methods.

In this study we register a relatively high (38%) degree of participation in organised PA once a week. On the other hand, no organised PA is mentioned by half of the respondents. Different results were obtained in a study by Duda (2006) who, during her observation of PA regarding respondents' professions found out that 14–17% of the respondents exercise once a week. She found out that 10% of teachers and up to 71% of nurses are engaged in PA irregularly. Respondents most often mentioned 2–3 times per week participation in sport and recreational exercise (Duda, 2006).

Participation in organised PA more than once a week is associated with an extensive increase in the number of steps per day (Sequeira, Rickenbach, Wietlisbach, Tullen, & Schutz, 1995). Participation in leisure time PA more than doubly increases the chance to meet the standard of 10 thousand steps daily (McCormack, Giles-Corti, & Milligan, 2006). We obtained similar results in our study when we found out that organised PA 1–2 times per week increases, by more than four times, the chance of meeting healthy criterion for PA. If we deal with the influence of organised PA on one's total PA on particular days, then we can say that organised PA expressively increases the number of realised steps per sport/exercise day as compared to days with

non participation in organised PA. These differences are more considerable in men than in women. Until recently the emphasis was put on the realisation of PA three and more times per week (WHO, 2009) for at least 10-minute periods (Strath, Holleman, Ronis, Swartz, & Richardson, 2008). Currently, the summation of PA performed at intervals shorter than 10 minutes are supposed to be beneficial. Moreover, it is evident that participation in PA once a week markedly contributes to meeting the healthy criterion of 10 thousands steps daily.

Analysis on individual days showed that respondents reach the lowest level of PA on Monday and Sunday. One study that compared the realised number of steps in relationship to the participants' weight came up with the same results. In respondents with normal weight a lower number of steps was registered on Monday and Sunday as compared to other days of the week. In overweight people the lowest number of steps was observed on Sunday (Clemes, Griffiths, & Hamilton, 2007). In our society Sunday is regarded as a day for relaxing, not only due to the Christian tradition but also for the reason of preparation for the following working day. Evidently we cannot expect, on this day, a significant change in movement behaviour. On the other hand, the men and women who participate in organised PA on Friday reached the highest number of steps. Friday afternoon provides a bigger opportunity for PA realisation or participation in cultural events due to the following free day as compared to other working days. With regard to technological possibilities allowing for the analysing of PA each day, the classification of days into working and weekend days seems to be insufficient

Regardless of participation in organised PA men performed 11,200 steps/day and women performed 10,612 steps/day on average. Bohannon (2007) or McCormack, Giles-Corti, and Milligan (2006) found a lower mean number of steps/day in women and men but, as in our study, they confirm the effect of age and BMI on meeting the standard of 10 thousand steps per day. Moreover, FCA proved that with increasing frequency of their participation in organised PA, the occurrence of overweight and obesity in people declines. The decline is less significant in men than in women.

LIMITATIONS

The main limitation of this study is the fact that the people who agreed to participate in this research and who finished the monitoring are those who are physically more active to begin with. A mean value of PA can be slightly overvalued and the observed differences smaller than in reality. Furthermore, in this study we did not observe the influence of profession on leisure

time PA. Another limitation is the absence of data about the available offerings of organised forms of PA in the respondents' places of residence.

CONCLUSIONS AND RECOMMENDATIONS

For a detailed understanding and the visualisation of results we recommend using a combination of statistical and other assessment methods, as for instance a combination of regression analysis and FCA. Participation in organised PA at least once a week positively influences meeting the healthy criterion of 10 thousand steps per day. For increasing the number of people participating in organised PA and increasing the chance of meeting the healthy criterion for PA it is necessary that attractive forms of PA be extended and offered, especially for overweight and obese people, people older than 26 years of age and for women.

Next research projects in this field should take into account the influence of profession on total PA together with participation in organised PA. Furthermore it is warranted to study the association between the total quantity of realised PA and the offerings of organised PA in the place of residence as well as considering people's participation in this PA.

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MÍRA VLIVU

ORGANIZOVANÉ POHYBOVÉ AKTIVITY NA DOSAŽENÍ ZDRAVOTNÍHO KRITÉRIA 10 000 KROKŮ DENNĚ: VYUŽITÍ REGRESNÍ A FORMÁLNÍ KONCEPTUÁLNÍ ANALÝZY (Souhrn anglického textu)

VÝCHODISKA: Organizovaná pohybová aktivita (PA) patří mezi faktory výrazně ovlivňující celkové množství realizované PA.

CÍLE: Cílem této práce je kombinací klasických statistických metod a formální konceptuální analýzy (FCA) zjistit, do jaké míry ovlivňuje organizovaná pohybová aktivita dosažení zdravotního kritéria 10 tis. kroků denně v konkrétním dni. Jaká týdenní frekvence účasti

v organizované PA je přínosná pro dosažení zdravotního kritéria.

METODIKA: Výzkumu se účastnilo 1749 mužů a 2293 žen ve věku od 12 do 84 let, jejichž týdenní PA byla monitorována pomocí krokoměru Yamax Digi-walker SW700. K hodnocení dat byla využita logistická regrese a FCA. Organizovaná PA výrazně zvyšuje počet realizovaných kroků ve dni s účastí v organizované PA oproti dnům s neúčastí v organizované PA.

VÝSLEDKY: Logistická regrese odhalila, že účast v organizované PA 1–2× týdně víc jak čtyřnásobně zvyšuje šanci dosáhnout zdravotního kritéria. Muži mají zhruba o 30 % větší šanci dosáhnout hranice 10 tisíc kroků denně než ženy. Lidé s normální hmotností mají tuto šanci největší, naopak šance na dosažení zdravotního kritéria je u obézních lidí nejmenší. Dle FCA dochází k výraznému nárůstu pravděpodobnosti plnění zdravotního kritéria 10 tis. kroků denně u žen až od čtenosti účasti v organizované PA 4× týdně (88 % proti 66 %), zatímco u mužů již od účasti 3× týdně (91 % proti 70 %).

ZÁVĚRY: Pro lepší pochopení výsledků doporučujeme využít kombinace statistických a dalších vyhodnocovacích metod, jako je např. FCA. Účast v organizované PA 1× týdně už pozitivně ovlivňuje dosažení zdravotního kritéria.

Klíčová slova: krokoměr Yamax, logistická regrese, věk, obezita, fuzzy logika.

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Scientific orientation

Scientific-explorational activity in the field of kinanthropology with orientation on statistical analysis and regional aspects of physical activity. Teaching practise

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