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Body dimensions and weight to height indices in rescuers from the State Fire Service of Poland

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Abstract: Few studies have been published in Poland concerning body dimensions of firefighters from the State Fire Service although this knowledge is needed for e.g. development of personal protective equipment. The aim of the study was to evaluate body dimensions and weight-to-height ratio in firefighters from the State Fire Service. Using the anthropological procedures, body mass (BM) and body height (BH) were examined in 178 men at the chronological age (CA) of 19.5 to 53 years who were rescuers from the national rescue and fire brigades of the State Fire Service. The study participants were divided into three categories of CA: up to 25 years, between 24 and 44 years, and over 44 years. The results were compared to population standards. It was found that BH of the youngest rescuers was significantly higher (0.05) than in other study participants. Based on the standardized values of BM and BMI, population of firefighters aged over 25 years was found to be characterized by overweight and, in certain cases, even by obesity. The excess level of body mass index (BMI ≥ 25 kgm^2) was found in nearly 60% of study participants, with half of the group classified as overweight (n=31, BMI ranging from 25 to 29.9 kg/m^2), and 10% classified as obese. Due to the worrying high percentage of cases of excess body mass in firefighters from the State Fire Service, it was found that it is recommended to evaluate the relationships between body height and mass on regular basis during periodical obligatory tests of physical fitness of rescuers from the State Fire Service and to increase the frequency and duration of training sessions.

Key words: firefighters, body measurements, body mass index, overweight

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Introduction

The number of employees in the State Fire Service of Poland is 30 thousand people, with most working in rescue and fire brigades. Physical properties of firefighters and rescuers, such as body build, fitness and physical capacity, and their equipment and level of vocational preparation determine successful rescue actions, where lives of victims often have to be saved. It was assumed that the auxological evaluation of firefighters, who represent the professional group with significant importance to society, will be useful for the development of personal protective equipment for rescuers and identification of the criteria for evaluation of fitness and physical capacity of firefighters. Therefore the results of our study can contribute to implementation of solutions to improve public safety. Furthermore, the study documented body measurements of the individuals from a specific professional group, which, through reference to other researchers, allows for observation of the effect of secular variation. It should be emphasized that the firefighters from the State Fire Service have been periodically tested for physical fitness, with the test protocol consisting in performance of a specific set of tasks i.e. physical fitness test battery (see: Ministry of the Interior and Administration, Act of 21 December 2015 and 27 October 2005). It should also be stressed that regular evaluation of physical fitness should take into consideration body measurements rather than merely sex and age (WHO Report No. 854 1995; Wareham at al. 1998; Craig and Russell 1999; Brudecki and Chrzanowska 2015). Consequently, the evaluation of performing a specific fitness test should take into consideration the relationships between body weight and height (weight to height ratio) although for the purposes of using fitness test batteries, such as Eurofit and the International Physical Fitness Test, the growth charts and algorithms have been developed to support evaluation of a person with respect to his or her weight to height ratio (Przewęda and Dobosz 2005; Dobosz et al. 2015).

An important impulse for preparation of this study was the fact that despite social importance of services in the State Fire Service, few Polish publications have focused on the evaluation of body measurements of firefighters (Pawłowski 1977; Michnik 2000; Sterkowicz 2000; Bertrand et al. 2011). It turned out that only one of the previous studies presented the results of body height measurements (BH, cm) and body mass (BM, kg) among ordinary firefighters who served in firefighting brigades of the State Fire Service (Michnik 2000). Furthermore, one study described BH and BM of firefighting university students while another study, published 40 years ago, documented body measurements of candidates for the firefighting school (Pawłowski 1977; Bertrand et al. 2011). Furthermore, Sterkowicz (2000), who was one of the researchers to examine body dimensions of firefighters, presented the group of participants of firefighting competitions. As can be expected, these people differ from other rescuers in their regular involvement in athletic training (Sterkowicz 2000). In his publication, however, Sterkowicz (2000) did not compare body dimensions of people who were not involved in firefighting sports, whereas body mass of the firefighters was similar to that found in a cohort of ordinary rescuers of the State Fire Service examined by Michnik (2000, see: Table 3).

Over 40 years, Polish reviewed journals have published barely four studies that have documented body measurements of firefighters from the State Fire Service. With this insignificant number of publications, we decided to refer body measurements of firefighters to measurements of people from other similar professional groups, such as policemen and soldiers. It was found that the increase in the number of data sets concerning body dimensions of the individuals involved in professions that require psychophysical traits similar to firefighters would provide a more comprehensive picture of the discussed population of firefighters from the State Fire Service.

Aim of the Study

Evaluation of body size and weight to height ratios in firefighters from the State Fire Service through reference of the results to population standards with consideration for generational differences and comparison of our own results with those presented by other researchers in Poland over the last several decades concerning body measurements of firefighters from State Fire Service in Poland.

Material and Methods

Study participants: a cohort of 178 men with chronological age (CA) ranging from 19.5 to 53 years who are rescuers from the national rescue and fire brigades of the State Fire Service in Poland.

Material: measurements of body height and body mass, and the computed body mass index (BMI).

Methods

The study protocol and measurement methods were accepted by the Ethical Commissions for Assessment of Biomedical Examinations at the Military Institute of Aviation Medicine in Warsaw. All the firefighters volunteered for the measurements and, before the examinations, they were informed in detail about the aim and procedures of the research program. Information about the aim and procedure was provided each time by the same researcher (Andrzej Wiśniewski). Study participants signed the written informed consent for participation in the examinations accepted by the Ethical Commissions for Assessment of Biomedical Examinations at the Military Institute of Aviation Medicine in Warsaw.

All the measurements were performed in the morning, with the same measurement equipment. Body height (BH) was measured using the wall stadiometer with accuracy of 0.1 cm. The study participants were wearing sportswear and were barefoot and without socks. During the measurement, the participant was positioned in the anthropometric Frankfurt position: standing in a relaxed upright position, back facing the ruler, with upper limbs relaxed and remaining along the body sides and lower limbs together and straight. The participants were asked to distribute weight equally on both feet and keep them V-shaped (heels together and forefoot slightly apart). The head of the participant was positioned at the eye and ear plane so that they looked to the point on the opposite wall at their eye height. Before the 1st and 2nd and before the 2nd and 3rd measurements, the participant was asked to perform a relaxed walk (ca. 5 m) in the measurement room and the result of the measurement was computed as an arithmetic mean of the three consecutive BH measurements. Body mass measurements were performed by means of body composition

analyser (electronic scales). The participants were wearing sportswear and were barefoot and without socks, after putting aside all the personal items. Body mass (BM) measurement was recorded with the accuracy of 0.1 kg.

The results of BH and BM measurements were used to compute body mass index (quotient of body mass expressed in kilograms and squared body mass expressed in metres, kg/m^2), and compared to the population standards developed by Palczewska and Niedźwiecka based on the examinations conducted in 1996-1999 (Warsaw's population, results published in 2000-2001). Further in the text, mean values of body mass index (BMI, kg/m^2) will be presented without units (Stupnicki et al. 2003). The relationships between weight and height were evaluated using the Ferro-Luzzi (1992) classification recommended by the World Health Organization (WHO). Based on this classification, BMI values ranging from 18.5 to 24.9 were considered as correct, those ranging from 25.0 to 29.9 pointed to overweight, and those from 30.0 to 39.9 were indicating obesity.

The evaluation of the effect of secular trends on body measurements, BH, BM and BMI for all study participants were referred to standards developed 20 years ago by Palczewska and Niedźwiedzka (2001) in the group of the youngest firefighters (CA<25years) were also referred to the standards developed by Kułaga et al. (anthropological measurements performed in 2007-2009, publication in 2010), whereas the oldest group (CA>44 years) was referred to the standards developed by Kurniewicz-Witczakowa et al. (1983). In order to express the measurement results as standard deviation score (SDS), they were transformed by means of the mean value and one standard deviation (SD) developed for 18-year men from the three above populations (Kurniewicz-Witczakowa et al. 1983; Palczewska and Niedźwiecka 2001; Kułaga et al. 2011). Using the population standards that reflect body dimensions over the last 50 years resulted from the fact that the evaluation of the material was conducted for the three age ranges: the youngest rescuers (CA<25.0 years), people aged from 25 to 44 years and the oldest group with CA over 44 years. The youngest group of rescuers were firefighting students or firefighters who were recently employed in rescue and firefighting brigades of the State Fire Service.

Statistical Analysis

The data about body size were collected and organized in Excel database. The comparative analysis of body height, body mass and weight to height indices was based on the one-way analysis of variance (ANOVA). The post-hoc Tukey test was used to detect significant differences between individual means of the parameters measured.

Prevalence of measurements below and over 2.0 SD was computed for each group and compared by means of the chi-squared test. Level of significance was set at $p<0.05$. Statistical calculations were performed by means of the STATISTICA 12 software.

Results

Mean values of body height and body mass measurements of all study participants and the firefighters from individual categories of the chronological age are presented in Table 1.

Table 1. Height, weight and body mass index (BMI) by age group in the rescuers from the State Fire Service of Poland

Age group (years)	Body height (cm)	Body mass (kg)	BMI (kg/m^2)
< 25 years n=75			
Mean±SD 21.77±1.43	180.93±6.66	79.74±8.26	24.34±1.90
Min-Max 19.46 - 24.92	167.2 - 198.0	63.0 - 103.6	19.9 - 28.9
25 - 44 years n=79			
Mean±SD 36.94±5.43	176.68±5.21	85.72±10.32	26.82±2.79
Min-Max 25.00 - 43.77	165.0 - 192.0	64.0 - 117.0	20.9 - 34.9
> 44 years n=24			
Mean±SD 48.88±2.37	178.57±5.08	91.04±14.99	28.44±3.84
Min-Max 44.25 - 53.26	167.0 - 187.3	67.6 - 119.6	22.9 - 36.7
Total n=178			
Mean±SD 31.89±9.99	179.61±5.93	83.92±10.97	25.99±3.02
Min-Max 19.46 - 53.26	165.0 - 198.0	63.9 - 119.6	19.9 - 36.7

Furthermore, Table 2. contain only mean standardized values of BH, BM and BMI expressed as standard deviation score (SDS).

One-way analysis of variance (ANOVA) revealed that the standardized body height measurements in the group of firefighters (BH SDS) in selected groups differed significantly ($F_{2.175;0.05}$=3.28). The post-hoc Tukey's test showed that mean standardized BH in the group of the youngest firefighters was significantly higher than in other classes of rescuers (p<0.05). It should be noted that in the younger category (CA<25 years), nearly 11% (n=8) of study participants had BH greater than 2 SDS for the general population, whereas in the category of 25 to 44 years, only one individual was very tall (BH>2.0 SDS). Furthermore, it was emphasized that among the oldest firefighters, the individual with the highest BH was evaluated at merely 1.4 and 1.6 SDS based on the standards developed based on the examinations conducted in 1996-1999 (Palczewska and Niedźwiedzka 2001) and in the seventies of the last century (Kurniewicz-Witczakowska et al. 1983), respectively. Apart from one case (0.6% of all the participants), no very short people (BH<-2.0 SDS) were found in the cohort studied.

Statistically significant differences were also observed during the analysis of standardized body mass values in selected classes of CA ($F_{2.175;0.05}$=13.14). It turned out that the youngest firefighters were characterized by significantly lower body mass compared to other groups (p<0.001). It was found that body mass of study participants increased with age as did consequently BMI. Comparison of the results of BM to the standards developed at the end of the last century (1996-1999) revealed significant differences (p<0.001) between the percentage of people with BM greater than 2 SD in the groups studied. It was found that in

Table 2. Standardized values of height, weight and body mass index (BMI) in rescuers from the State Fire Service of Poland referred to the population reference values developed by other researchers

Age group (years)	Body height (cm) Mean±SD Min-Max	Body mass (kg) Mean±SD Min-Max	BMI (kg/m^2) Mean±SD Min-Max
< 25 years n=75			
SDS$^{\#}$	0.39±1.04^{aa} -1.76 - 3.07	1.08±0.83^{aaa} -0.60 - 3.48	1.00±0.71^{ddd} -0.64 - 2.72
SDS$^{\#\#}$	0.37±1.03 -1.74 - ±3.00	0.72±0.70^{bbb} -0.70 - 2.75	0.62±0.57^{eee} -0.72 - 2.01
SDS$^{\#\#\#}$	NA	NA	NA
25 - 44 years n=79			
SDS$^{\#}$	0.04±0.82 -2.02 - 2.21	1.68±1.04^{ccc} -0.50 - 4.83	1.93±1.04 -0.25 - 4.96
SDS$^{\#\#}$	NA	NA	NA
SDS$^{\#\#\#}$	NA	NA	NA
> 44 years n=24			
SDS$^{\#}$	0.02±0.80 -1.69 - 1.39	2.22±1.51 -0.14 - 5.09	2.53±1.43 0.48 - 5.60
SDS$^{\#\#}$	NA	NA	NA
SDS$^{\#\#\#}$	0.28±0.79 -1.44 - 1.64	3.47±2.08 0.21 - 7.43	NA
Total n=178			
SDS$^{\#}$	0.19±0.93 -2.02 - 3.07	1.50±1.10 -0.60 - 5.09	1.62±1.12 -0.64 - 5.60
SDS$^{\#\#}$	NA	NA	NA
SDS$^{\#\#\#}$	NA	NA	NA

Notes: SDS – *Standard Deviation Score*; $^{\#}$ – referred to the population standards for body height developed by Palczewska and Niedźwiecka and published in 2001; $^{\#\#}$ – reference values for BH developed by Kułaga et al. and published in 2010; $^{\#\#\#}$ – referred to the population standards developed by Kurniewicz-Witczakowa et al. and published in 1983; NA – data not available; ^{aa} – standardized body height of rescuers from the CA<25 years, significantly greater than in those from CA 25 to 44 years and CA>44 years, $p<0{,}01$; ^{aaa} – standardized body mass of rescuers from the CA<25 years, significantly greater than in those from CA 25 to 44 years and CA>44 years, $p<0.001$; ^{bbb} – standardized body mass of rescuers from the CA<25 years, significantly greater than in those from CA 25 to 44 years and CA>44 years, $p<0.001$; ^{ccc} – standardized BM of the rescures from the group of CA 25 to 44 years significantly lower than in the group of CA>44 years, $p<0.001$; ^{ddd} – standardized body mass index for the youngest participants significantly lower than for firefighters from the group of CA 25 to 44 years and CA>44 years, $p<0.001$; ^{eee} – standardized body mass index for the youngest participants significantly lower than for firefighters from the group of CA 25 to 44 years and CA>44 years, $p<0.001$.

the youngest group, only 11% (8 of 75%) had BM exceeding 2.0 SDS, whereas in both older subgroups, the percentage of such people was nearly 37% (29 of 79 in CA category of 25 to 44 years) and 54% (13 of 24 people for CA>44 years). Similar to body mass, significant differences were also found between the standardized values of BMI ($F_{2.175;0.05}$ =29.17) between the CA groups. It was demonstrated that mean BMI in the youngest group was significantly lower ($p<0.001$) than in both older groups. In the subgroup of the youngest rescuers, only slightly fewer than 5% (n=4) of participants had BMI greater than 2.0 SDS, whereas in the age categories of 25 to 44 years and over 44 years, this value was nearly 46% (n=36) and 58% (n=14).

Discussion

The material collected was mainly evaluated by the analysis of BH, BM and BMI referred to the national population standards. As mentioned before, we used three different standards to refer body size metrics of the study participants to populations of individuals of the same age as firefighters studied. Another objective of the analysis was to compare body size of the men from the cohort studied with the results documented by other Polish researchers. Accordingly, a database search was performed, but few Polish publications (see: Table 3) containing body size metrics of firefighters or students of firefighting universities were found. Therefore, due to insuffi-

Table 3. Body size measurements in rescuers and individuals from other vocational groups in studies published by Polish authors

Source, years of the study, sample size	Age (years) Mean±SD	Body height (cm) Mean±SD	Body mass (kg) Mean±SD	BMI (kg/m^2) Mean±SD
Firefighters				
Michnik 2000 1995-1997, n=402	18.53-54.03*	175.2±5.94	80.8±10.76	NA
Michnik 2000 1995-1997, n=281[A]	18.53-54.03*	175.2±5.83	81.24±10.98	NA
Michnik 2000 1995-1997, n=80[B]	18.53-54.03*	175.2±6.24	79.53±10.04	NA
Sterkowicz 2000 1995, n=56[C]	30.51±3.02	177.79±5.37	78.59±7.47	NA
Firefighting students				
Bertrand et al. 2011 2009, n=80[D], 2010, n=80[E]	19.4±0.9[D] 19.3±0.92[E]	179.7±5.7[D] 180.9±5.7[E]	76.1±6.9[D] 77.6±7.1[E]	NA NA
Pawłowski 1974, 1977 n=136[F]	NA	175.15±5.37	71.79±7.08	NA
Rescuers from other formations				
Kaca et al. 2011 2006, n=34[G]	20.97±3.17 17-30*	181.33±5.34	65.33±5.88	NA
Soldiers, policemen, pilots				
Ziółkowska-Łajp 1998 n=63[H]	NA	174.88±6.17	76.80±8.96	NA
Jasiński and Tkachuk 2004 1992-2002, n=4274[I]	36.99±7.71	175.6±6.21	77.63±10.64	25.16±3.14
Jasiński and Tkachuk 2004 1992-2002, n=5537[J]	36.55±7.87	176.1±6.395	77.53±10.06	25.01±2.92

Contiuned Table 3

Tomczak and Haponik 2016 2014, n=120[K]	37.13±5.42	178.65±5.20	86.57±10.94	27.12±3.23
Kłos et al. 2007 n=105[L], CA up to 30 years	25.3±2.61	175.7± 5.57	80.5±10.4	NA
Kłos et al. 2007 n=46[M], CA 31-40 years	33.2±2.27	175.9±5.68	83.05±10.4	NA
Tomczak et al. 2014 2014, n=20[N]	30.0±3.4	179.5±6.56	85.8±10.00	NA
Pietraszewska et al. 2012 n=25[O]	29-40*	177.6±7.45	88.2±12.20	27.99±3.66
Pietraszewska et al. 2012 n=27[P]	29-40*	177.62±5.18	81.42±9.67	25.75±2.99
Wasiluk 2010 2006, n=3425[Q]	18.68±0.31	177.63±6.38	69.76±3.29	22.09±3.29
Kłos et al. 2015 n=122[R], CA 21-25 years	23.9±1.2	180.9±3.0	83.3±10.4	25.5±3.0
Kłos et al. 2015 n=120[R], CA 26-30 years	27.8±1.3	181.7±3.4	85.5±9.3	25.9±2.7
Kłos et al. 2015 n=44[R], CA 31-44 years	34.4±2.8	180.0±5.6	86.2±10.3	26.5±2.8
Kłos et al. 2015 n=14[R], CA>44 years	44.9±3.0	178.5±6.4	84.4±17.3	26.5±4.5
Choła et al. 2013 n=19[S], CA>26 years	25.79±0.42	179.0±7.33	84.16±8.37	26.27±2.27
Choła et al. 2013 n=15[T], CA<26 years	31.93±2.52	178.8±5.63	81.47±6.93	26.24±2.28

Notes: The table shows when the authors performed the measurements if the information was provided; CA - chronological age, years; * - range of chronological age; [A] - only rescuers from operating units separated from a cohort of 402 study participants; [B] - only individuals with mixed working mode who were the rescuers from the State Fire Service selected from the cohort of 402 study participant; the author provided no definition of the mixed working mode; [C] - firefighters with working experience of 9.6 years, participants of 12th Poland Firefighting Sports Championships; [D] - measurements of students in 2009; [E] - measurements of students in 2010; [F] - the author provided mean BH and BM of the candidates for the Main School of Fire Service in 1971-1974; the table presents the data only for the year 1974; [G] - rescuers of the Volunteer Water Rescue Service (WOPR) examined during water rescue competition; [H] - fighter pilots; [I] and [J] - military and civil pilots, respectively; [K] - fighter pilots; [L] and [M] - members of the naval ship crews aged up to 30 years and in the group of CA 31-40 years, respectively; [N] - no mean BMI was provided, the figure presents percentage of people from BMI classes separated in the publication; [N] - soldiers from GROM military unit; [O] and [P] - policemen and soldiers, respectively; [Q] - military recruits born in 1987; [R] - soldiers from the Representative Battalion of the Polish Army divided into four categories of the chronological age; [S, T] - soldiers serving in the War in Afghanistan, group I [(S)] age>26 years, group II[(T)] age<26 years; NA - Data not available.

cient amount of data, we collected other publications that have documented body dimensions of representatives of other professions where regular physical exercise is required.

As mentioned before, Polish authors (Pawłowski 1977; Michnik 2000; Sterkowicz 2000; Bertrand et al. 2011) who presented body measurements of firefighters have failed to refer the results to population standards (they did not standardize the measurement results) but also did not analyse weight to height ratios. Therefore, it was found that the only method to compare body dimensions in the cohort studied with firefighters examined 20 years before was to discuss body height and body mass separately, as it had been done in previous publications. This form of publication is also justified by the fact of strong habit of practitioners to evaluate only one characteristic of the person studied, i.e. body mass. With both above reasons, the study text represents the compromise between the correctness of body mass evaluation (recommended as related to body height) of the study participants and the need to attract the reader's attention to the worrying tendencies for being overweight in the population of rescuers from the State Fire Service in Poland. The study demon-

strated that both evaluation of only body mass and the analysis of weight to height ratios performed based on BMI reflect the strong tendency for excessive body mass in the population of firefighters. This conclusion, as stressed before, is especially important and should be addressed first and foremost to practitioners and representatives of administration. It should also be emphasized that we approached body mass index mainly as a tool to evaluate the risk of diseases of affluence in a population (Drygas 2005; Brudecki and Chrzanowska 2015).

Body height

As mentioned before, previous Polish authors who have documented body height of firefighters from the State Fire Service in Poland have failed to refer their results to the population standards, which represents a novelty of the present study. Referring of the results of body height measurements to population standards allowed for comparison of people whose dates of birth differed by over 30 years since the youngest participants were born on 1997 while the oldest in 1962. With this varied age group, it was found necessary to refer body dimensions to the standards developed over the last several decades. Regardless of age, all study participants were assessed by referring their body size metrics to the population standards based on the measurements performed in 1996-1999 since we found that only this national standard could be considered a "gold" standard (Palczewska and Niedźwiecka 2001). This was justified by the fact that when the standard was developed, the youngest participants in the cohort were just born and three fourth of them were aged from a few years to 18 years. Furthermore, body measurements of the oldest (CA>44 years) firefighters, born between 1962 and 1971, were referred to the standards developed based on the measurements performed in 1976-1980 (Kurniewicz-Witczakowa et al. 1983), i.e. the CA closest to this class. Furthermore, body dimensions of the youngest participants (CA<25 years) were referred to the values presented relatively recently by Kułaga et al. (2011) based on studies conducted in 2005 and 2006. The above method allowed for the objective comparison of the standardized body height of firefighters from the cohort with substantially varied age, especially the youngest and oldest participants. As mentioned before, the youngest participants were substantially taller than older ones (0.05), which can be viewed as a reflection of secular trends of body height in the Polish male population. This fact was often discussed in the literature (Szklarska et al. 2004; NCD-RisC 2016), and the global phenomenon caused that mean body height of young people in the Polish population is currently greater than in older individuals born 40 years ago (population standards for BH of the 18-year old men: 178.5 *versus* 176.5 cm) (Palczewska and Niedźwiecka 2001; Kurniewicz-Witczakowa et al. 1983). Despite the documented effect of secular trends on body size of people in various geographical and economic zones (NCD-RisC 2016), it was surprising to find that their strength is so high in the Polish population. This is reflected by comparison of body height of firefighters in the studies conducted 20 years ago (1995-97) by Michnik (2000). It was observed that mean body height in both cohorts is substantially different (179.6 *versus* 175.2 cm; 0.001) whereas the ranges of the chronological age are similar. Therefore, over the 20 years of

the effects of the secular trends, mean body mass of men who started working as firefighters increased significantly with respect to rescuers with long professional experience. Similarly expressed differences (0.001) were found by comparison of the category of the youngest participants from the cohort of firefighters with those who applied for admission to firefighting university courses in 1974, that is, 40 years ago (Pawłowski 1977). Interestingly, the mean body height of young men who applied for the status of a firefighting student in 1974 was similar to the body height of the firefighters examined 20 year later in the cohort presented by Michnik (2000). An objective assessment of this observation and determination of the secular trends is even more difficult as Michnik (2000) failed to divide his study participants into categories (giving only the age range for the entire cohort).

It was also found interesting that body height of students of firefighting courses examined by Bertrand et al. in 2009-2010 (2011) and the youngest firefighters (CA<25 years) in our study (2015-2016) turned out to be similar, whereas in both cases measurements concerned students of the same university i.e. the Main School of Fire Service in Warsaw. The above observation may suggest the disappearing or weaker effect of secular trends on body height of men in Poland. It is also worth emphasizing the statistically significant differences between body height of military recruits from the voivodeships of the eastern part of Poland (Wasiluk 2010, n=3425) and students from the Main School of Fire Service from the study by Bertrand et al. (2011) (significance of the difference: 0.01) and our own study (significance of the difference of 0.001 between recruits and firefighters in the category of CA<25 years). Mean body height of recruits turned out to be smaller with respect to both listed groups of students-firefighters with merely 3 years of difference between the periods of the study conducted by Wasiluk (published in 2010, see: Table 3) and Bertrand et al. (published in 2011) (see: Table 3). Therefore, lower body height of military recruits from the eastern regions of Poland compared to university students from firefighting courses can reflect the presence of variation of body height of residents from various regions of Poland.

It was found that the above presented observations justify the periodically repeated (e.g. every 10 years) comprehensive anthropological measurements of body size metrics and development of population-based standards. Knowledge of current body dimensions in the population living in a specific country region is used to e.g. adjust and/or design workplaces, protective clothing, tools and daily necessities. Furthermore, because it was observed that every tenth firefighter from the youngest group is very tall (BH>2 SDS), it seemed reasonable to postulate examinations on the relationships between body height and aptitudes to perform standardized rescue activities.

Body mass

It was found that regardless of the population standards used to refer the measurement results, the group of the youngest firefighters was characterized by significantly lower body mass compared to older ones. The phenomenon of the BM increasing with age was found to be very pronounced. The standardized BM mean of the oldest firefighters was not only substantially greater (0.001) than in the medium subgroup (CA of 25

to 44 years) but also substantially high. It was found that it was over 2 SDS in the case of standardization with the standards from 1996-1999 (Palczewska and Niedźwiecka 2001) and even 3.5 SDS compared to the population standards from 1976-1980 (Kurniewicz-Witczakowa et al. 1983) (BM 2.22 *versus* 3.47 SDS, $p<0.001$). Over half of the oldest firefighters (n=13 of 24) were characterized by body mass greater than 2 SDS, whereas a third of them had (n=8) BM greater than 3 SDS (for this category, BM>99 kg). Therefore, it should be noted that the group of the oldest rescuers from the State Fire Service was characterized by overweight or obesity. It is remarkable that in the group of the youngest (CA<25 years) firefighters, the value of the standardized BM was greater than 3SD in only one individual, but this person was characterized by proper weight to height ratios (BH 3.1 SDS at BM 3.5 SDS). It was also observed that CA in the people from the cohort studied was significantly positively correlated (0.366, $p<0.001$) with their body mass. Therefore, the phenomenon of the worrying excessive increase in body mass was found in individuals from rescue and firefighting brigades. It should be emphasized that body mass which substantially exceeds the standard for the population (e.g. 69 kg for 18-year old men according to Palczewska and Niedźwiedzka in the Warsaw's population (2001) and 71 kg according to Kułaga et al. (2011) in the Polish population) is reflected by high mass of the skeletal muscles only in insignificant percentage of adult men. Presence of excess body mass with regard to the population standards is usually caused by excess fat percentage of the person and rarely the manifestation of a substantial skeletal muscle mass (Rywik 2002; Kaczmarczyk-Chałas and Drygas 2003; Biela et al. 2005; Drygas 2005; Sakowska and Wojtyniak 2008). It should be stressed that the study did not analyse the lifestyles of the firefighters. However, it is most likely that the lifestyles were the major causes of overweight and obesity in the rescuers from the State Fire Service. As often demonstrated in studies (Kohl et al. 2012; Flint et al. 2014; Flint and Cummins 2016), excess fat percentage is attributable to chronic excessive energy supply with diets compared to energy expenditure during physical activity. Therefore, presence of excess fat percentage in the representatives of such vocational groups as soldiers, policemen and rescuers from various formations, reflects indirectly the deficiency of regular physical exercise. It should also be stressed that only careful organization and regular training sessions can be effective in maintaining healthy fat percentage in body composition. This was clearly demonstrated in the publication by Landsberg et al. (2008), who compared body fat percentage in students divided into groups depending on the method used to commute to school. These researchers found that only few students were characterized by a healthy body fat percentage in body composition. This group were commuting to school by walking or cycling over the significantly longer distances compared to others. Everyday physical activity of these students was found by Landsberg et al. (2008) as a fundamental health factor. It is remarkable that fat percentage was similar in the students who walked or cycled to school over short distances (short exercise without spending much energy) compared to those picked up by cars or commuting by municipal public transport.

It was also found that mean body mass of the firefighters from the State Fire Service was significantly greater than in men weighed in Poland by other researchers at least more than ten years ago (see: Table 3; Pawłowski 1977; Ziółkowska-Łajp 1998; Michnik 2000; Sterkowicz 2000; Jasiński and Tkachuk 2004). However, this value was similar when compared to a few recent years (see: Table 3; Kłos et al. 2007; Pietraszewska et al. 2012; Choła et al. 2013; Tomczak et al. 2014; Kłos and al. 2015; Tomczak and Haponik 2016). However, the rescuers from the Volunteer Water Rescue Service (Wodne Ochotnicze Pogotowe Ratunkowe, WOPR) weighed in 2006 by Kaca (2011) were characterized by "low" body mass compared to firefighters in our own study (BM 65.3 *versus* nearly 84 kg, $p<0.001$) and to soldiers analysed by Kłos et al. (2007), Pietraszewska et al. (2012), Choła et al. (2013), Kłos et al. (2015), Tomczak and Haponik (2016). It should be emphasized that the value of mean BM in the rescuers from the Volunteer Water Rescue Service (Kaca et al. 2011) is maintained between 25th and 50th centile according to Palczewska and Niedźwiedzka (2001:52), thus being within the standard range for adult men. In the case of rescuers from the Volunteer Water Rescue Service who participated in water rescue competition, the factor which was conducive to maintaining proper body mass was regular physical exercise the rescuers-athletes were involved in. Therefore, it was found that the observations can be approached as arguments for a more rigorous testing thresholds for evaluation of body mass during periodical physical fitness tests for rescuers from the State Fire Service and organization of regular physical training sessions in all units of the State Fire Service.

Relationships between weight and height

The results of weighing should be routinely referred to body height of the person studied in order to avoid mistakes during interpretation of body mass. Various methods to express weight to height ratios have been proposed in recent years, with some examples being the index body mass related to squared body height, termed body mass index (BMI) (Ferro-Luzzi et al. 1992; WHO Report No. 854 1995; Brudecki and Chrzanowska 2015). Analysis of the measurement results revealed a tendency for deterioration in body mass to body height ratio in study participants. As stressed before, similar relationships were found for body mass. It was observed that BMI was significantly correlated ($p<0.001$, $r=0.509$) with chronological age of the firefighters. Using the criteria for BMI interpretation developed by the WHO experts, none of the study participants were characterized by insufficient body mass compared to body height. It was surprising that the excess level of body mass index (BMI ≥ 25) was found in nearly 60% of study participants, with half of the group classified as overweight (n=31, BMI ranging from 25 to 29.9), and 10% classified as obese. Among the obese individuals, grade 1 obesity was dominant (n=15, BMI 30 to 34.5), but some were qualified even to the grade 2 obesity group. (n=3, BMI 35 to 39.9). The relatively recently proposed the BMI 27.5 threshold value for people aged over 35 years (Mansoubi et al. 2015; Milewicz 2015) was used to evaluate the risk of diseases of affluence (the term is still in use in Polish publications, also on the website of the Ministry of Health of the Republic of Poland, although it has been already replaced by the term

non-communicable diseases in foreign studies). People aged over 35 years represented nearly half of the study participants (n=82) in the cohort studied and it turned out that using the criterion of BMI 27.5, over half of them (n=42) should be considered as exposed to increased risk of non-communicable diseases. Therefore, it can be reasonably expected that the risk of the negative effect of excess body mass on the health status of rescuers from the State Fire Service should intensify as a person ages (Pająk et al. 2005; Milewicz 2015). It should also be emphasized that the evaluation of the level of risk of non-communicable diseases in the population studied will be more informative if it is extended with body composition analysis, which will be presented in another publication.

Comparison of mean BMI values in our study with those presented by other authors led to the conclusions similar to evaluation of body mass. The authors who have published the measurement results obtained in the last decade (see: Table 3, Pietraszewska et al. 2012; Kłos et al. 2015; Tomczak and Haponik 2016) have documented similar BMI as in our study (firefighters from the State Fire Service). Even comparison with the group of the oldest firefighters, which was characterized by the very high BMI with the soldiers from the Representative Battalion of the Polish Army (Kłos et al. 2015) did not show the significance of differences (BMI 28.4 in our study *versus* 26.6 in the soldiers in CA>44 years). Furthermore, mean BMI in a cohort of pilots examined by Jasiński and Tkachuk in 1992-2002 (published in 2004) were found to be significantly lower (0.001) than in firefighters from the State Fire Service aged over 25 years. Therefore, the above observation confirms the fact of the presence, in the Polish population, of the phenomenon of the overly increasing body mass, most likely due to the higher prevalence of sedentary lifestyle behaviours (Kaczmarczyk-Chałas and Drygas 2003; Szklarska et al. 2004; Drygas 2005; Pająk et al. 2005; Biela et al. 2005; Sakowska and Wojtyniak 2008; Kłosiewicz-Latoszek 2010; Milewicz 2015).

Conclusion

Based on the analysis of body size measurement results obtained for the rescuers from the State Fire Service, the needs arise for:

1. Periodical updating of knowledge about current body size measurements in the Polish population since population standards are often used in various domains of life, also those connected with organization of the national rescue system;

2. Research on the relationships between body height and the method of performing standard rescue activities by firefighters from the State Fire Service because every tenth firefighter aged up to 25 years is very tall;

3. In-depth evaluation of the relationships between body height and body mass during periodical physical activity tests performed among the rescuers of the State Fire Service because a very high number of cases of excess body mass was found in firefighters aged over 25 years, which is closely linked to the risk of non-communicable diseases.

Authors' contributions

AW conception and design of the work, data collection, data analysis and interpretation, drafting the article, critical revision of the article; WJ data collection,

critical revision of the article; AC, AM, MS, AM data collection, data analysis and interpretation, , critical revision of the article; PK data collection, DZ-R data analysis and interpretation, MK final approval of the version to be published.

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Conflict of interest

The Authors confirm that there are no known conflicts of interest associated with this publication.

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