Received: 8 May 2018 | Revised: 2 November 2018 | Accepted: 3 December 2018

DOI: 10.1111/sms.13376

ORIGINAL ARTICLE

WILEY

Development of physical fitness performance in young Swiss men from 2006 to 2015

Thomas Wyss[1] | **Lilian Roos**[1] | **Fabian Studer**[1] | **Urs Mäder**[1] | **Christiane Beuchat**[1] | **Kaspar Staub**[2]

[1]Swiss Federal Institute of Sport Magglingen SFISM, Magglingen, Switzerland

[2]Institute of Evolutionary Medicine IEM, University of Zurich, Zurich, Switzerland

Correspondence
Thomas Wyss, Swiss Federal Institute of Sport Magglingen SFISM, Magglingen, Switzerland.
Email: Thomas.wyss@baspo.admin.ch

From 1980 to 2000, physical fitness decreased and body mass index (BMI) increased in the population of many industrialized countries. Little is known about these trends after the year 2000. This study aimed to investigate physical fitness performance, physical activity (PA) behavior, and BMI of young, male Swiss adults between 2006 and 2015. For this purpose, results from the Swiss Armed Forces mandatory recruitment were used. A total of 306 746 male conscripts provided complete fitness test data, mean ± SD (range from 5th to 95th percentile): 20 ± 1 (18-21) years, 178 ± 7 (168-189) cm; 74 ± 13 (58-97) kg, predicted maximal oxygen consumption of 49.9 ± 4.6 (41.8-56.9) mL/kg/min (Conconi test), 125 ± 58 (43-232) seconds in trunk muscle strength test (prone bridge), 2.31 ± 0.24 (1.90-2.66) m in standing long jump, 6.46 ± 0.73 (5.30-7.70) m in seated shot put (2 kg medical-ball shot) and 45.6 ± 12.2 (29.9-66.7) seconds in one-leg standing test (sum of both legs; eyes closed after 10 seconds and head tilted back after 20 seconds). In the investigated population, 73.8% fulfilled basic PA recommendations, 46.2% were classified as regularly vigorously active. Performances in aerobic endurance and muscle power did not show secular changes over time. However, core stability performance and PA behavior increased, while balance ability decreased over this 10-year period. Average BMI increased by 2.0% between 2006 and 2010 and did not change thereafter. Male Swiss adults are at least as physically fit as they were a decade ago. The secular trends of decreasing physical performances and increasing BMI have stopped, and self-reported sport participation and leisure time PA have been increased in the observed population over the last 10 years.

KEYWORDS
fitness, fitness development, physical activity behavior, physical fitness, population health

1 | INTRODUCTION

Regarding public health and national defense prospective, data on the population's physical fitness, anthropometrics, and physical activity (PA) behavior are important because of the strong relation to health outcomes an military performance. Long-term monitoring of such data can be used as an indicator of a specific population's health status. During the two decades before the turn of the millennium, physical fitness decreased and body weight increased in the population of industrialized countries in Europe and Asia, as well as America.[1-8] Many countries increased their efforts in the promotion of PA and sport based on these results. Therefore, it would be of great interest if the secular trend of decreasing physical fitness and increasing body mass could be reversed in some western countries.

The authors of the Non Chronic Diseases (NCD) Risk Factor Collaboration study, which comprised 19.2 million participants, found no change in the trend of increasing body mass after the year 2000, whether viewed from a global perspective nor by focus on the industrialized countries noted above.[7] However, other data indicate in the Finnish and Swiss populations that the trend of increasing proportion of overweight in adults has flattened or stopped since 2007 and 2009, respectively.[9-11] Yet no relevant change of trend was demonstrated for physical fitness values in any industrialized country. Physical fitness continued to decrease since the millennium as demonstrated for the two populations of Finland and China. It has to be considered, that for physical fitness less epidemiological data is available than for body mass. A different picture shows the data on self-reported physical activity values. PA behavior has increased in some industrialized countries. The number of young adults who meet the leisure time PA recommendations increased in Finland and China between 2000 and 2014.[9,12,13]

In January 2006, a new physical performance test[14-16] and a self-report questionnaire on PA behavior were implemented in the Swiss Armed Forces (SAF) recruitment process. The study population of annually investigated 18-year-old men represented approximately 95% of this age group.[17] In total, the performance data from more than 300 000 male conscripts are available to investigate the development of physical fitness in general and in groups of the most and least fit subjects, in particular. Therefore, these data were available to be used to investigate the development of fitness in the Swiss population after the millennium. This study aimed to investigate how the PA behavior and physical fitness performance of young Swiss adults have changed in the last decade, using the SAF recruitment data.

2 | METHODS

2.1 | Study design and participants

The recruitment procedure of the SAF lasts for two days and takes place 3-12 months before the beginning of the military training school. At recruitment, medical, physical, and psychological assessments are performed. From 2006 to 2015, 392 087 male conscripts passed their compulsory recruitment for the SAF. In Switzerland, recruitment for the SAF is mandatory for all males aged 18 and older. Recruitment slightly before or later than the year they turn 19 years old is possible upon request. In this study, only data provided by conscripts aged between 18 and 23 years at recruitment were considered for analysis. All conscripts younger than 18 and older than 23 years were regarded as not representative, exceptional cases, explained by various reasons as early recruitment for air force selection or late recruitment after successful naturalization as a Swiss citizen before the conscripts' 27th birthday. Therefore, the data of 5165 (1.3%) conscripts were excluded because they were younger than 18 or older than 23 years at the time of recruitment. Of the remaining 387 659 male conscripts, 306 746 (79.1%) provided complete fitness test data, 305 719 (78.9%) provided data on PA behavior, and 366 349 (94.5%) provided measured BMI data. Only conscripts with a health-related dispensation by a medical doctor did not perform the physical fitness test. If not noted differently, all presented data are related to the group of conscripts that provided complete physical fitness test data.

2.2 | Ethical statement

The SAF have the authority to provide anonymized data for academic research (Swiss law, Bundesgesetz über die Miliätärischen Informationssysteme MIG, BG 510.91, Art. 2, 9, 24-29). Where analyses are based on such anonymized and nonclinical government data, ethical approval is not required (Swiss data privacy act, SR 235.1; 19.6.1992 and Federal Act on Research involving Human Beings HRA, 810.30; 1.1.2014). As conscription in Switzerland is mandatory and the anonymized data analyzed in this study fit the profile of observational (nonclinical) government data, informed consent was not required.

2.3 | Instruments

Professional and trained personnel instructed the conscripts regarding the fitness test battery. First, they provided a standardized warm-up with 6 minutes of running combined with aerobics and 6 minutes of functional calisthenics and active stretching. The following fitness test battery contained a progressive endurance run (PER) to measure aerobic endurance capacity, trunk muscle strength test (TMST) to assess trunk muscle fitness, standing long jump (SLJ), and a seated shotput (SSP) to register the muscle power of the lower and upper extremities, respectively, and a one-leg standing test (OLS) to measure balance. The PER is a paced running test, conducted according to the protocol developed by Conconi et al[18] and evaluated using the final running velocity. PER showed very good test-retest reliability ($r = 0.89$, $P < 0.001$) and concurrent validity ($r = 0.84$, $P < 0.001$) if compared to treadmill VO_2peak test.[14] In the TMST, the subject must hold an isometric body position (on forearms and feet with upper body and legs in a straight line, also called "prone bridge") for as long as possible while lifting their feet alternately. This specific test for trunk muscle fitness is of very strong test-retest reliability ($r = 0.85$, $P < 0.001$)[14] and of high criterion validity to explain injury risk and military performance (area under the receiver operation characteristic curve AUC = 0.58-0.68, $P < 0.05$, and AUC = 0.59, $P = 0.06$, respectively).[15,16] The TMST is also part of the standardized trunk muscle strength test battery of the Swiss Olympic Medical Centres and is validated for assessing trunk muscle fitness in athletes.[19,20] The SLJ was performed from the gym hall floor onto a mat of 7 cm height. The SLJ is of very strong test-retest reliability ($r = 0.90$, $P < 0.001$) and of strong to very strong concurrent validity ($r = 0.64$ and -0.73, $P < 0.001$) if compared to squat jump height and 40 m running time, respectively.[14] The SSP was performed as a chest pass with a 2-kg ball while sitting upright on a bench with the back in contact with a solid wall. This test is of very strong test-retest reliability and strong concurrent validity ($r = 0.83$, and 0.65, respectively, $P < 0.001$) if compared to maximal 30 kg bench press acceleration.[14] For the OLS, participants had to hold a position on one leg as long as possible; however, they had to close their eyes after 10 seconds and to tilt their head back with closed eyes after 20 seconds from the starting time. Time was registered for the left and right leg separately, and the sum of both was evaluated for balance. The test-retest reliability ($r = 0.50$, $P < 0.001$) of the OLS and its criterion validity to explain injury risk in solders (AUC = 0.57, $P = 0.06$) were demonstrated to be moderate.[14,21] Precise descriptions of the five tests and their power to predict injuries were previously published by the Swiss Federal Institute of Sport Magglingen SFISM.[14,16] Anthropometrics were measured by medically trained personnel during the medical examination. Body height and weight were measured using a stadiometer, and a calibrated scale, respectively. Thereof, BMI was calculated. PA behavior and an index for sport-related intentions were assessed using a self-report questionnaire, including the International Physical Activity Questionnaire short-form (IPAQ short)[22] and further statements on sport-related intensions. The test-retest reliability and concurrent validity of the IPAQ short was shown to be strong (pooled Spearman's correlations of 0.76, and 0.67, respectively), and a weak criterion validity was demonstrated (pooled spearman correlations of 0.30).[22] Each sport-related intention statement was answered on a five-point Likert scale "I fully agree," "I agree," "I partially agree," "I disagree," and "I fully disagree." The 15 statements were as follows: "Sport allows me positive contact to other persons." "For me important people encourage me to be physically active." "I have the intension to increase my PA level in the next six months." "I dare to be regularly physically active in the coming years." "I will never be good in sports." "I do not have time for sport and PA." "I prefer other activities than sport." "I often feel a lack of energy." "Sport activities are too expensive for me." "I care about healthy nutrition." "Sport is healthy." "I enjoy sport." "During sport activities I do feel empowered." "Sport makes me feel good." "During sport I do forget other issues." These 15 statements were used to calculate an index for sport-related intentions [0-4 points each, 0-60 points in total].

2.4 | Data processing and statistical analysis

Based on PER data, the predicted maximal oxygen consumption (Pdt VO_2max) was calculated. The formula developed by Wyss et al[14] was then used: Pdt VO_2max [mL/kg min] = 0.02175 * PER [s] + 33.29. For visualization of relations between physical fitness, BMI and PA behavior, respective data were stratified: Pdt VO_2max data were stratified in quartiles with the subjects with the lowest endurance performance assigned to the first quartile and those with the best performance assigned to the fourth quartile. BMI data were stratified into nine groups (<18.5; 18.5-19.9, 20.0-22.4; 22.5-24.9; 25.0-29.9; 30.0-34.9; 35.0-39.9; ≥40 kg/m^2).The nine BMI categories follow the official WHO categories for underweight (<18.5 kg/m^2) and obesity grades I-III (≥30.0 kg/m^2), but additionally sub-divided the WHO normal-weight and overweight categories in steps of 2.5 kg/m^2 to account for non-linear associations between BMI and sport test results within these normal or slightly elevated BMI ranges. PA behavior was stratified into five categories based on the core document for Switzerland on health-enhancing physical activity[23]: regularly vigorously active individuals (sport or vigorous PA for at least three times per week), regularly active individuals meeting the national basic recommendations for health-enhancing PA[24] (at least five times 30-minute moderate PA per week), irregularly active individuals meeting the basic recommendations for health-enhancing PA (at least 150 minutes of moderate PA each week), partially active individuals not meeting the basic recommendations for health-enhancing PA (<150 minutes of PA per week) and inactive individuals (if <30 minutes of PA per week reported). Occupation and education was combined and allocated to four categories invented for the present study: high school degree, professionally educated and non-physically demanding job, professionally educated and physically demanding job, and no professional education. Existing International Standard Classification of Occupations (ISCO)-classified categories were not applicable since many conscripts had just graduated from high school but had not yet started university or a professional career. Based on the postal code of residence, conscripts were assigned to the four language regions (German, French, Italian, Romansh) and different levels of urbanicity (urban, suburban, and rural) in accordance with the official classifications of the Swiss Federal Statistical Office.[25] The unit percentage point is used to quantify the arithmetic difference of two percentages.

Statistical analyses were performed using IBM SPSS Statistics (version 24.0, IBM Corporation, Armonk NY, USA) with an alpha level of 0.05 to indicate statistical significance. Group results are presented as mean ± SD and 95%-Confidence Interval (95% CI), group comparisons were performed using ANOVA and Bonferroni's post hoc tests. Multivariate linear regression analysis with stepwise backward elimination was used to detect independent variables with significant influence on physical fitness performances. The potential independent predicting variables investigated were calendar year, BMI, sport intention, PA behavior, age, urbanicity, language regions, and occupation classification. Adjusted R^2 and β^2 were used to estimate explained variances of the dependent variable by all included, and by each independent variable, respectively. All potential predicting variables were tested for multicollinearity using Pearson's correlation coefficient.

3 | RESULTS

3.1 | Study population

The study population (n = 306 746) was, on average ± SD (range from 5th-95th-percentile), 19.6 ± 0.9 (18.4-21.4) years, 178.2 ± 6.5 (168.0-189.0) cm and 74.0 ± 12.5 (58.0-97.0) kg, with a BMI of 23.3 ± 3.6 (18.7-30.1) kg/m^2. The study population had a Pdt VO_2max of 49.9 ± 4.6 (41.8-56.9) mL/kg/min and performed 124.5 ± 57.7 (43.0-232.0) seconds at TMST, 2.31 ± 0.24 (1.90-2.66) m at SLJ, 6.46 ± 0.73 (5.30-7.70) m on the SSP and 45.6 ± 12.2 (29.9-66.7) seconds on the OLS. Standard values (percentiles) for the investigated study population, representing the young, male Swiss population, are provided in Table 1. In the investigated population, 93.0% of subjects provided data on PA behavior (n = 285 150). Hence, 73.8% fulfilled basic recommendations for health-enhancing PA, and 46.2% were classified as regularly vigorously active. Data of the subgroup of conscripts who were excluded from fitness testing at recruitment due to medical reasons, but who provided BMI (n = 59 790) or PA behavior (20 569) data, had a statistically significant higher BMI (23.8 ± 4.8; 18.4-32.7 kg/m^2, $P < 0.001$). This subgroup further included a statistically significant lower proportion of subjects classified as meeting basic recommendations for health-enhancing PA or classified as regularly vigorously active, respectively (48.5% and 27.8%, $P < 0.001$) compared to the investigated study population.

3.2 | Development of physical fitness performances in young Swiss men from 2006 to 2015

Pdt VO_2max and SSP performances did not show systematic secular changes over time. However, TMST performance showed a secular increase of 4.3%, while SLJ and OLS showed a secular decrease of 2.1% and 3.8%, respectively, from 2006 to 2015 ($P < 0.001$; Figure 1 and Table

TABLE 1 Fitness test standard values for young, male Swiss conscripts (n = 306 746, 19.6 ± 0.9 y, 178.2 ± 6.5 cm, 74.0 ± 12.5 kg)

Percentile	BMI [kg/m^2]	Pdt VO_2max [mL/kg/min]	TMST [s]	SLJ [m]	SSP [m]	OLS ($t_l + t_r$) [s]
5	18.7	41.8	43	1.90	5.30	29.9
10	19.5	43.7	56	2.00	5.56	32.3
15	20.1	45.1	65	2.07	5.72	34.3
20	20.5	46.1	74	2.12	5.88	36.1
25	20.9	46.9	82	2.16	6.00	37.9
30	21.2	47.8	90	2.20	6.10	39.1
35	21.6	48.4	98	2.25	6.17	40.4
40	22.0	49.0	103	2.27	6.27	41.8
45	22.3	49.8	111	2.30	6.35	43.0
50	22.6	50.4	121	2.33	6.45	44.2
55	23.0	50.9	130	2.35	6.52	45.6
60	23.4	51.6	132	2.40	6.60	47.0
65	23.8	52.0	138	2.41	6.70	48.1
70	24.3	52.5	146	2.44	6.80	49.5
75	24.9	53.2	156	2.47	6.90	51.0
80	25.6	53.8	165	2.50	7.03	52.8
85	26.5	54.6	183	2.55	7.20	55.1
90	27.8	55.5	201	2.60	7.40	59.0
95	30.1	56.9	232	2.66	7.70	66.7

BMI, body mass index; OLS, one-leg standing; Pdt VO_2max, predicted maximal oxygen consumption; SLJ, standing long jump; SSP, seated 2 kg shot put; TMST, trunk muscle strength test.

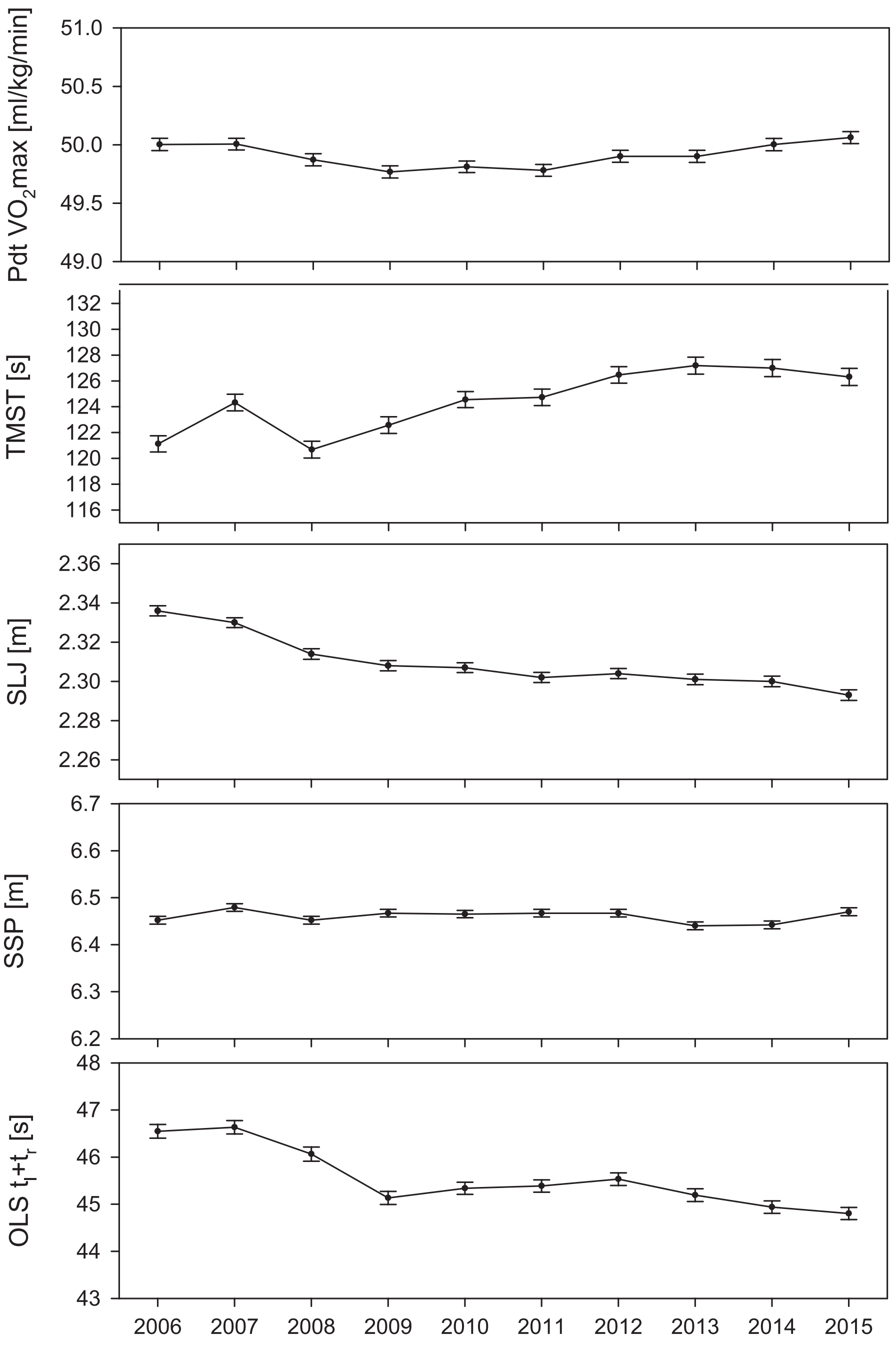

FIGURE 1 Development of physical fitness performance in young Swiss men from 2006 to 2015. Mean ± confidence interval for the mean. Pdt VO_2max, predicted maximal oxygen consumption; TMST, trunk muscle strength test; SLJ, standing long jump; SSP, seated 2 kg shot put; OLS, one-leg standing

S1). However, when the development of SLJ data was investigated for standardized BMI groups (18.5-20, 20-22.5 and 22.5-25 kg/m^2), no secular trend in SLJ performance was observed. At the same time, BMI values showed a secular increase of 2.0% between 2006 and 2010 and did not change after the year 2010. The proportion of young Swiss men that classified as regularly vigorously active and the proportion that classified as met the basic recommendations for health-enhancing PA showed a secular increase in 8.5% and 8.7% points from 2006 to 2015. Their ratings regarding sport-related intentions showed a secular increase of 6.6% ($P < 0.001$, Table 2) during the investigated decade.

3.3 | Linear regression to explain physical fitness performances

The independent variables investigated to predict physical fitness performances were calendar year, age, BMI, PA behavior, sport intension, language region of Switzerland, urban and rural areas, as well as job/education classification. The included independent variables explained 41% of the variance of Pdt VO_2max ($P < 0.001$). BMI, sport intention, and PA behavior explained about 14%, 10%, and 5% of the variance of Pdt VO_2max. Most of the other variables remained with significant influence in the final regression model; however, each predicted <1% of the variance of Pdt VO_2 max. Calendar year

TABLE 2 Development of physical activity behavior in Swiss men from 2006 to 2015. Proportion of men classified as regularly vigorously active and meeting basic physical activity recommendations and mean ± SD of sport intention values

Year	N	Regularly vigorously active [%]	Meeting PA Recommendations [%]	Sport intention [Index 0-60]
2006	20 533	41.5	68.8	42.8 ± 11.6
2007	24 619	42.7	69.8	43.1 ± 11.5
2008	28 391	44.0	71.1	43.5 ± 1 1.5
2009	29 558	43.8	71.6	43.9 ± 11.3
2010	32 284	44.7	73.0	44.3 ± 10.9
2011	30 915	46.7	74.6	44.6 ± 10.6
2012	30 497	47.1	74.9	44.8 ± 10.5
2013	28 954	48.7	76.1	45.4 ± 10.2
2014	29 687	51.0	78.1	45.7 ± 10.1
2015	29 712	50.0	77.5	45.6 ± 10.1
Overall	285 150	46.2	73.8	44.4 ± 10.8

TABLE 3 Linear regression with trunk muscle strength test performance as dependent variable

	B	SE	*β*	*T*	*P*	Explained variance [β^2]
Constant	145.268	0.838		173.361	0.000	
Calendar year	0.090	0.035	0.040	2.582	0.000	<1%
BMI	−4.574	0.027	−0.282	−169.807	0.000	8%
Sport intention	1.286	0.011	0.241	121.669	0.000	6%
PA behavior	6.907	0.079	0.173	87.871	0.000	3%
Urban, suburban, rural	4.198	0.132	0.054	31.88	0.000	<1%
French SR Switzerland	−1.68	0.242	−0.012	−6.953	0.000	<1%
Italian SR Switzerland	−3.696	0.492	−0.013	−7.505	0.000	<1%
Romansh SR Switzerland	6.869	1.316	0.009	5.219	0.000	<1%
No professional education	−9.937	0.354	−0.049	−28.043	0.000	<1%
PE NPD occupation	−11.169	0.258	−0.078	−43.266	0.000	1%
Students	−4.574	0.245	−0.035	−18.677	0.000	<1%

BMI, body mass index; PA, physical activity; PE NPD, professional educated, not physically demanding. Urban, suburban, rural is coded as 1, 2, and 3, respectively. The language regions of Switzerland were compared to German speaking region (SR) of Switzerland. Job classifications were compared to professionally educated, physically demanding occupation.

did not explain any variance of Pdt VO_2max. Conscripts from rural regions and with high school degree had 0.5 mL/kg/min higher Pdt VO_2max values as the other groups ($P < 0.001$). The above listed independent variables explained about 23% of TMST and SLJ performance, 20% of SSP performance, and 6% of OLS performance ($P < 0.001$). As reported above, BMI, sport intention, and PA behavior predicted most of the observed variances of physical performances. For TMST, SLJ, and OLS, the calendar year remained a significant factor in the regression model but explained <1% of the variance of the respective physical performance values ($P < 0.001$). The final linear regression models for all physical fitness performances were similar to the data presented for TMST in Table 3. Age did not have any significant influence on physical performance in any model. Conscripts living in rural areas performed slightly better than conscripts from urban areas. The effect of the language regions remained in some models, but with very low influence on the observed variances. Conscripts with high school degrees

Self-reported PA level (IPAQ)	n	Pdt VO_2max	SD Pdt VO_2max
Very low PA level	29 673	46.43	4.40
Low PA level	45 120	47.95	4.11
Medium PA level	61 698	49.64	4.09
High PA level	16 872	49.94	4.13
Trained	131 787	51.73	4.16
Meeting PA recommendations			
No	74 793	47.35	4.29
Yes	210 357	50.98	4.26
Total	285 150	50.02	4.56

SD, standard deviation. VO_2max differed between all groups significantly ($P < 0.001$, ANOVA, Bonferroni's post hoc).

TABLE 4 Relation between stratified physical activity (PA) level and predicted (Pdt) maximal oxygen consumption (VO_2max). Conscripts' PA level was assessed by the short version of the International Physical Activity Questionnaire (IPAQ)

(students) or working in professionally educated and physically demanding jobs performed slightly better than conscripts working in professionally educated but non-physically demanding jobs or without any professional education.

3.4 | Physical fitness, PA recommendations and BMI

A significant relation of moderate correlation magnitude between PA level and Pdt VO_2max as well as TMST performance was observed ($r = 0.40$, and $r = 0.31$, $P < 0.001$). Further, a significant relation of small correlation magnitude was observed between PA level and SLJ, SSP, and OLS performances ($r = 0.24$, $r = 0.22$, and $r = 0.11$, respectively, $P < 0.001$). The higher the PA level, the better the fitness performances (for Pdt VO_2max performance Table 4). Conscripts meeting the basic recommendations for health-enhancing PA and conscripts classified as regularly vigorously active had a 7% and 10%, respectively, higher Pdt VO_2max value ($P < 0.001$) compared to their peers. Further, a strong—but not linear—relation between BMI and physical fitness performances was observed. The group of conscripts with a BMI between 20 and 22.5 kg/m^2 showed significantly higher Pdt VO_2max values (51.3 ± 4.1 mL/kg/min, $P < 0.001$) than any other stratified BMI group presented in Figure 2. The same pattern was observed for the other four physical fitness tests as well. A similar—but not linear—relation was observed between BMI and PA behavior. However, the group with the highest proportion of regularly vigorously active and physically active conscripts was found for the stratified BMI group of 22.5-25 kg/m^2 (Figure 3).

4 | DISCUSSION

The test performances for aerobic endurance and muscle power did not show systematic changes from 2006 to 2015. However, core stability performance and the proportion of young men classified as regularly vigorously active increased linearly while balance ability decreased over this 10-year period. From all investigated independent variables, BMI, sports-related intensions and PA behavior do have the strongest relation to fitness performance. However, the relation between BMI and fitness performance is not linear. The group of conscripts with a BMI between 20 and 22.5 kg/m^2 showed the highest aerobic fitness. Further, conscripts living in rural areas performed slightly better than conscripts from urban areas and conscripts with high school degrees or in professionally educated and physically demanding jobs performed slightly better than conscripts in professionally educated but non-physically demanding jobs or without any professional education.

4.1 | Physical fitness performances

Between 2006 and 2015, the aerobic endurance capacity (Pdt VO_2max) in Swiss conscripts stayed constant. Thus, the secular trend of continuous decrease of aerobic fitness, observed in many industrialized countries since 1980, has stopped in young Swiss men. Based on the results of a prior study, the change of this trend in Switzerland has happened in 2002,[8] and aerobic fitness performances of Swiss conscripts has been stable since. To the authors' knowledge, this stabilization of aerobic fitness level has not yet been demonstrated in any other industrialized country. However, a similar trend was observed in Finnish conscripts, with a slower decrease in 12 minutes running performance after the year 2000.[9]

The present study observed no specific trend in muscle power adaptations during the last decade. SSP performance showed no trend; however SLJ showed a small but significant decrease between 2006 and 2015 in Swiss conscripts. This result is likely not related to reduce in muscle power, but related to increase in body mass. As assumed, if data analysis was controlled for BMI, no significant secular decrease in SLJ performance was found anymore. Results from prior studies

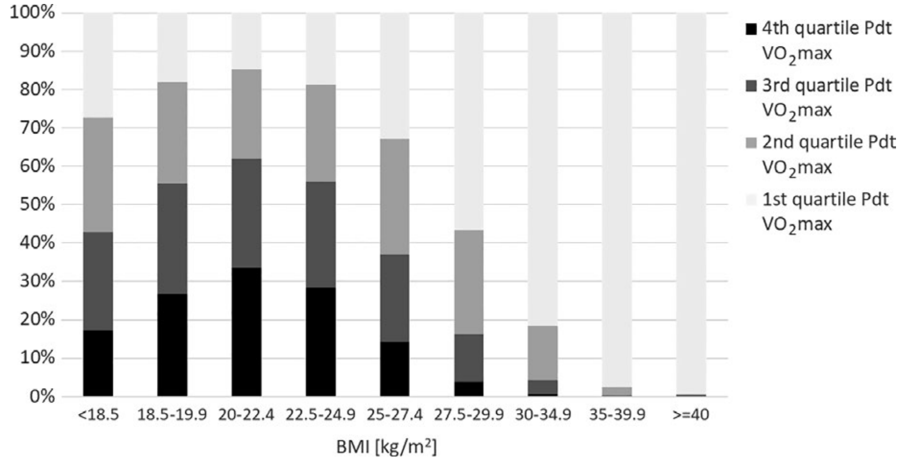

FIGURE 2 Relation between body mass index (BMI) and predicted (Pdt) maximal oxygen consumption (VO_2max). Conscripts with best VO_2max performances were stratified in the fourth quartile of Pdt VO_2max (first Quartile = low Pdt VO_2max, fourth Quartile = high Pdt VO_2max)

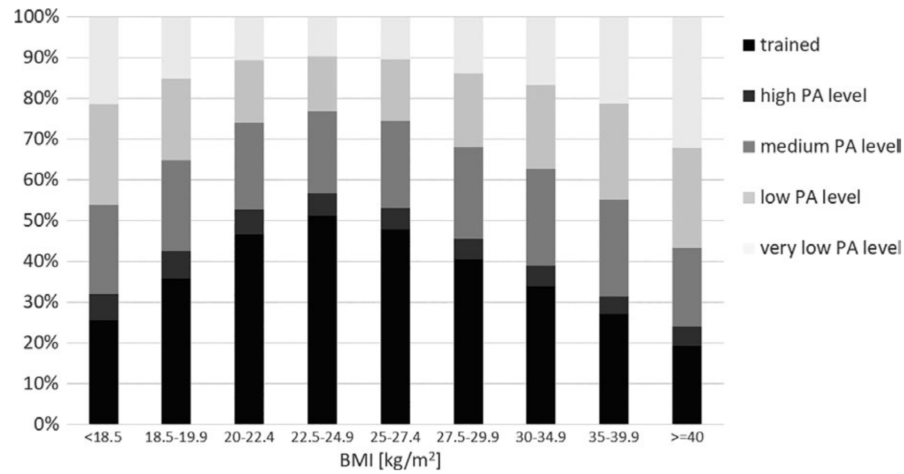

FIGURE 3 Relation between body mass index (BMI) and physical activity (PA) level. Conscripts' PA level was assessed by the short version of the International Physical Activity Questionnaire (IPAQ). Conscripts classified as trained, with high and medium PA level met the PA recommendations

supported this hypotheses by demonstrating a significant negative correlation between jump performances (SLJ or vertical jump) and BMI (moderate correlation magnitude), as well as body fat (high correlation magnitude), respectively.[26,27]

However, a significant, strong secular increase in core strength (TMST performance), and secular decrease in balance ability (OLS performance) were recorded in Swiss conscripts over the last decade. These results might relate to adaptations in sport participation and the physical training behavior of young Swiss citizens. A national survey of sport participation in Swiss citizens aged 15-19 years demonstrated a relevant increase in individualized fitness training of about 10% (fitness and weight training, running, swimming, and aerobics) at the expense of team sport participation, with a decrease of up to −4% (volleyball, basketball, floorball, and soccer) between 2008 and 2014.[28] With a shift from movement-diversified team sport activities to more unilateral strength and endurance training, a decrease in motor control and, therefore, balance ability, as well as an increase in trunk muscle strength, seems to be reasonable. A decrease in balance ability (flamingo balance test) was reported in Flemish adolescents (17 years) already from 1980 to 2005.[29] Prior studies showed large secular variability in balance performances. On average, a decline in balance was demonstrated in European children from 1992 to 2002; however, in Lithuanians, the opposite was investigated.[30] Further, and more recent data on secular trends of balance ability and motor control from different countries are needed.

Compared to median values of physical performances in different European countries and Australia, young Swiss citizens display similar, or slightly better performances. However, the comparison of median performance data between countries must be interpreted with caution. The age groups differ slightly (17 years vs 19 years). Furthermore, different testing protocols, medical dispensations processes, and data cleaning limit the comparability. Unfortunately, absolute VO_2max data presented in this study cannot be compared to the values assessed in Finnish and Norwegian conscripts,[9,31] because the latter used an ergometer-based endurance test. A bicycle ergometer protocol does result in lower VO_2max values compared to a running test protocol.[32] With the mentioned reservations in mind, the present study reported higher aerobic and muscular fitness with a median of Pdt VO_2max in young Swiss men of 50 mL/kg/min (Table 1) compared to 45 mL/kg/min in Europe and Australia.[33,34] Further, the median of SLJ performance in young Swiss men was found to be 2.3 m (Table 1) compared to 2.2 m in Finland,[9] and 2.1 m averaged over different European countries.[33]

4.2 | Physical activity behavior

The proportion of young Swiss men classified as regularly vigorously active or meeting the basic recommendations for health-enhancing PA, as well as their values for sport intention, increased greatly over the past 10 years. These results demonstrate the increasing importance of sport participation and leisure time PA in Swiss society. The same trend was demonstrated in the Finnish population by an increase in leisure time PA, while commuting and occupational PA decreased concurrently between 1982 and 2012.[13] The present study and Dyrstad et al[31] demonstrate a comparable, weak to moderate relation between PA behavior and physical fitness. Therefore, one can conclude that the increase in sport participation and leisure time PA over the last decade is responsible for the favorable change in physical fitness development of the Swiss population, despite decreases in commuting and occupational PA.

4.3 | Limitations and strengths of the study

With more than 300 000 participants, the present study included a large number of subjects. However, data are representative of male Swiss citizens with an age from 18 to 23 years only; since SAF recruitment applies only to males, similar representative data for females are not available. The migration background of the conscripts cannot be assessed. For aerobic fitness, direct measures of VO_2max were not feasible in testing more than 30 000 men each year. However, the used Conconi test is of good validity to predict VO_2max.[14,18] Furthermore, BMI is not an ideal indicator for body composition because it cannot differ between body weight caused by muscle and body weight caused by fat mass. However, recent research on waist circumference of the Swiss conscripts shows that this misclassification issue of BMI is probably limited to the lower overweight range (25.0-27.5 kg/m^2).[35] Unfortunately, as an index for PA, no objective data were available. Data of self-report questionnaires as the IPAQ short do show only moderate correlations to objective data.[36] However, such self-report questionnaires and particular the IPAQ are frequently used in large epidemiological studies. Unfortunately, due to data storage and transfer from the SAF to the SFISM, questionnaire data had to be reduced to two variables. It was therefore decided to stratify the physical activity questions to the five activity classes[23] and to sum up the 15 questions on sport-related intentions to one total score after data collection in the recruitment centers and to store and transfer only the processed questionnaire data. Therefore, single questions cannot be investigated in the present study and no other stratification of PA behavior is available for data analysis.

5 | CONCLUSION AND PERSPECTIVE

From a national health promotion and defense perspective, long-term monitoring of PA and PF is important as an indicator of a population's health and military readiness status. Young Swiss men are at least as physically fit as they were a decade ago. The trends of decreased physical performance and increased BMI values were halted in Switzerland. At the same time, sport participation, leisure time PA, and sport-related intentions have increased in young men over the last 10 years. The efforts supporting PA and sport promotion in Switzerland might have been partly responsible for the positive trend in this specific group. The importance of sport and leisure time PA has grown in the general Swiss society during this years.[37] The present results might therefore be good news. However, it is the opinion of the authors, that these positive results do not yet compensate the challenges in today's health promotion and national defense efforts. Military organizations continue to be challenged by large differences between physical demands in military occupations and physical capabilities in conscripts and soldiers. Military organizations still have to find ways to increase their soldier's physical fitness prior to military service and they have to adapt the first weeks of basic military training according to the capabilities of their conscripts. For individual preparation prior to military service, some armed forces have developed or are developing mobile training applications. It will be of great interest, if such new approaches or other population-based sports promotion programs do have any effect on physical fitness performance in our future generations. Therefore, additional to epidemiological studies as the present, studies on causality between activity promotion programs and subjects behavior are needed.[38]

ORCID

Thomas Wyss https://orcid.org/0000-0002-6068-477X
Lilian Roos https://orcid.org/0000-0001-7442-0751

REFERENCES

1. Sorensen HT, Sabroe S, Gillman M, et al. Continued increase in prevalence of obesity in Danish young men. *Int J Obes Relat Metab Disord*. 1997;21(8):712-714.

2. Rasmussen F, Johansson M, Hansen HO. Trends in overweight and obesity among 18-year-old males in Sweden between 1971 and 1995. *Acta Paediatr*. 1999;88(4):431-437.
3. Sharp MA, Patton JF, Knapik JJ, et al. Comparison of the physical fitness of men and women entering the U.S. Army: 1978-1998. *Med Sci Sports Exerc*. 2002;34(2):356-363.
4. Santtila M, Kyrolainen H, Vasankari T, et al. Physical fitness profiles in young Finnish men during the years 1975-2004. *Med Sci Sports Exerc*. 2006;38(11):1990-1994.
5. Stratton G, Canoy D, Boddy LM, Taylor SR, Hackett AF, Buchan IE. Cardiorespiratory fitness and body mass index of 9-11-year-old English children: a serial cross-sectional study from 1998 to 2004. *Int J Obes (Lond)*. 2007;31(7):1172-1178.
6. Tomkinson GR, Olds TS, Kang SJ, Kim DY. Secular trends in the aerobic fitness test performance and body mass index of Korean children and adolescents (1968-2000). *Int J Sports Med*. 2007;28(4):314-320.
7. NCD Risk Factor Collaboration. Trends in adult body-mass index in 200 countries from 1975 to 2014: a pooled analysis of 1698 population-based measurement studies with 19.2 million participants. *Lancet*. 2016;387(10026):1377-1396.
8. Wyss T, Beuchat C, Zehr S, Mäder U. Physical performance in young men at Swiss Army recruitment 1982 to 2005. *Schweiz Z Sportmed Sporttraumatol*. 2009;57(2):75-77.
9. Santtila M, Pihlainen K, Koski H, Vasankar T, Kyröläinen H. Physical fitness in young men between 1975 and 2015 with a focus on the years 2005-2015. *Med Sci Sports Exerc*. 2018;50:292-298.
10. Staub K, Wyss T, Lehmann S, Abel T, Rühli F. Die gesundheit junger schweizer männer: monitoring-ergebnisse der armeerekrutierung. *Praxis*. 2015;104(22):8.
11. Staub K, Bender N, Floris J, Pfister C, Ruhli FJ. From Undernutrition to Overnutrition: the evolution of overweight and obesity among young men in Switzerland since the 19th century. *Obes Facts*. 2016;9(4):259-272.
12. Tian Y, Jiang C, Wang M, et al. BMI, leisure-time physical activity, and physical fitness in adults in China: results from a series of national surveys, 2000-14. *Lancet Diabetes Endocrinol*. 2016;4(6):487-497.
13. Borodulin K, Harald K, Jousilahti P, Laatikainen T, Mannisto S, Vartiainen E. Time trends in physical activity from 1982 to 2012 in Finland. *Scand J Med Sci Sports*. 2016;26(1):93-100.
14. Wyss T, Marti B, Rossi S, Kohler U, Mäder U. Assembling and verification of a fitness test battery for the recruitment of the Swiss army and nation-wide use. *Swiss J Sports Med Sports Traumat*. 2007;55(4):126-131.
15. Wunderlin S, Roos L, Roth R, Faude O, Frey F, Wyss T. Trunk muscle strength tests to predict injuries, attrition and military ability in soldiers. *J Sports Med Phys Fitness*. 2015;55(5):535-543.
16. Wyss T, Von Vigier RO, Frey F, Mader U. The Swiss Army physical fitness test battery predicts risk of overuse injuries among recruits. *J Sports Med Phys Fitness*. 2012;52(5):513-521.
17. Panczak R, Zwahlen M, Woitek U, Ruhli FJ, Staub K. Socioeconomic, temporal and regional variation in body mass index among 188,537 Swiss male conscripts born between 1986 and 1992. *PLoS ONE*. 2014;9(5):e96721.
18. Conconi F, Ferrari M, Ziglio PG, Droghetti P, Codeca L. Determination of the anaerobic threshold by a noninvasive field test in runners. *J Appl Physiol*. 1982;52(4):869-873.
19. Bourban P, Hübner K, Tschopp M, Marti B. Grundkraftanforderungen im spitzensport: ergebnisse eines 3-teiligen rumpfkrafttests. *Schweiz Z Sportmed Sporttraumatol*. 2001;49:73-78.
20. Tschopp M, Bouban P, Hübner K, Marti B. Messgenauigkeit eines 4-teiligen, standartisierten dynamischen rumpfkrafttests: erfahrungen mit gesunden männlichen spitzensportlern. *Schweiz Z Sportmed Sporttraumatol*. 2001;49:67-72.
21. Wyss T, Roos L, Wunderlin S, Mäder U. Comparison of two balance tests to predict injury risk in a military setting. Abstractbook of the ECSS (17th annual Congress of the European College of Sport Science); 2012.
22. Craig CL, Marshall AL, Sjostrom M, et al. International physical activity questionnaire: 12-country reliability and validity. *Med Sci Sports Exerc*. 2003;35(8):1381-1395.
23. Martin Diener E, Martin B, Hodel M, Mäder U. Health-Enhancing Physical Activity, Core Document for Switzerland. H.a.P.A.N.S. Federal Office of Sport FOSPO, Federal Office of Public Health FOPH, Health Promotion Switzerland, bfu-Swiss Council for Accident Prevention, Swiss Accident Insurance Fund (Suva), Editor. Magglingen: Federal Office of Sport (FOSPO), 2013; p. 32.
24. Federal Office of Sport FOSPO, Federal Office of Public Health FOPH, Health Promotion Switzerland, bfu-Swiss Council for Accident Prevention, Swiss Accident Insurance Fund (Suva), Health and Physical Activity Network Switzerland. Health-enhancing physical activity. Magglingen: FOSPO; 2013.
25. Swiss Federal Statistical Office. Nomenklaturen. 2018. https://opendata.swiss/de/dataset/amtliches-gemeindeverzeichnis-der-schweiz-stand-vom-01-01-2006 Accessed April 05, 2018.
26. Bialoskorska M, Tomczyk E, Tomczyk A, Szafraniec R. Relations between vertical jump hight and volleyball players body composition. *Sci Rev Phys Culture*. 2016;6(1):56-62.
27. Nikolaidis PT, Asadi A, Santos EJ, et al. Relationship of body mass status with running and jumping performances in young basketball players. *Muscles Ligaments Tendons J*. 2015;5(3):187-194.
28. Lamprecht M, Fischer A, Wiegand D, Stamm H. Sport Switzerland 2014: children and youth report. Series sport Switzerland 2014: children and youth report, ed. Series Editor. Vol. Volume. 2015, Magglingen, Switzerland.
29. Matton L, Duvigneaud N, Wijndaele K, et al. Secular trends in anthropometric characteristics, physical fitness, physical activity, and biological maturation in Flemish adolescents between 1969 and 2005. *Am J Hum Biol*. 2007;19(3):345-357.
30. Jurimae T, Volbekiene V, Jurimae J, Tomkinson GR. Changes in Eurofit test performance of Estonian and Lithuanian children and adolescents (1992-2002). *Med Sport Sci*. 2007;50:129-142.
31. Dyrstad SM, Anderssen SA, Edvardsen E, Hansen BH. Cardiorespiratory fitness in groups with different physical activity levels. *Scand J Med Sci Sports*. 2016;26(3):291-298.
32. Miyamura M, Honda Y. Oxygen intake and cardiac output during maximal treadmill and bicycle exercise. *J Appl Physiol*. 1972;32(2):185-188.
33. Tomkinson GR, Carver KD, Atkinson F, et al. European normative values for physical fitness in children and adolescents aged 9-17 years: results from 2 779 165 Eurofit performances representing 30 countries. *Br J Sports Med*. 2017;52(22):1445-14563.
34. Catley MJ, Tomkinson GR. Normative health-related fitness values for children: analysis of 85347 test results on 9-17-year-old Australians since 1985. *Br J Sports Med*. 2013;47(2):98-108.

35. Staub K, Floris J, Koepke N, et al. Associations between anthropometric indices, blood pressure and physical fitness performance in young Swiss men: a cross-sectional study. *BMJ Open*. 2018;8(6):e018664-9.
36. Mader U, Martin BW, Schutz Y, Marti B. Validity of four short physical activity questionnaires in middle-aged persons. *Med Sci Sports Exerc*. 2006;38(7):1255-1266.
37. Lamprecht M, Fischer A, Stamm HP.Sport Schweiz 2014: Sportaktivität und Sportinteresse der Schweizer. Bevölkerung, S.F.O.o. Sport, Editor. Magglingen; 2014.
38. Dössegger A, Weibel D, Frei KM, Wissmath B, Hense J. Entwicklung eines wirkmodells für die evaluation des programms jugend und sport. *Evaluation*. 2017;16(1):24.

SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

How to cite this article: Wyss T, Roos L, Studer F, Mäder U, Beuchat C, Staub K. Development of physical fitness performance in young Swiss men from 2006 to 2015. *Scand J Med Sci Sports*. 2019;29:586–596. https://doi.org/10.1111/sms.13376