Impact of Training Patterns on Injury Incidences in 12 Swiss Army Basic Military Training Schools

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ABSTRACT Non-battle injury rates are a major health problem in the armed forces today. Injury rates are related to physical demands of daily military routine. The aim of this study is to investigate the impact of different physical training patterns on incidences of injuries in 12 Swiss Army basic military training schools. Therefore, injury data of 1,676 voluntary participant recruits and objective sensor data on physical demands of 50 volunteers at each of 12 trainings schools were assembled. Multiple linear regression showed that high physical demands, decreasing development of distances covered on foot, monotony in weekly physical demands, little time spent on sport-related physical training, and little time for night rest were significant risk factors for injuries. Together, those variables describe 98.8% of the variances of total injury incidence rate between military training schools. The new method used to objectively assess training demands allowed this study to investigate the impact of training patterns on injury incidence in a large number of training schools. The results of this study are important for future interventions to reduce injury incidence rates in a military setting by quantifying the injury risk potential of a large number of training patterns.

INTRODUCTION

A basic issue of every military organization is to balance physically demanding job requirements and soldiers' physical capabilities to prevent health complaints, especially non-battle injuries.[1–8] According to Anderson et al,[9] specific patterns in physical training (PT) activities are related to injury incidences in the setting of team sports. Training patterns in their study were quantified as training load, activity type and duration, monotony, and periodization of PT activities. Using new body-worn sensor methods to objectively monitor physical demands on large groups of trainees,[10,11] training patterns can be investigated in a military setting. This study aims to investigate the impact of PT patterns in 12 Swiss Army basic military training (BMT) schools on incidence of injuries. Physical training patterns in each training school were investigated, parameters quantifying training load were assessed (physical activity energy expenditure [PAEE] and distance covered on foot [DOF]), parameters quantifying activity type and duration were assessed (time spent on physically demanding materials handling activities [MHA], sport-related PT, inactivity, and night rest), and parameters quantifying periodization of physical activities (monotony and development in weekly PAEE and DOF).

METHOD

Study Design and Participants

All recruits of 12 Swiss Army training schools were asked to volunteer in this study. The schools investigated trained rescue technicians, armored infantry, reconnaissance infantry, and fusilier infantry BMT. The participants received comprehensive oral and written information and provided written informed consent for their participation as approved by the Cantonal Ethics Committees of Bern, Aargau, St. Gallen, and Waadt. Volunteers' age, anthropometry, and physical fitness were assessed before military service. Physical activities and training demands were investigated using body-worn sensors during the first 10 weeks of BMT in 50 volunteers of each training school. These volunteers were randomly selected from all volunteers within each training school. They were asked to wear a heart rate monitor on the chest, an acceleration monitor on the hip, and a second acceleration monitor on the backpack during wake time. Injury occurrence among all volunteers was continuously assessed by the medical staff over 18 weeks of BMT.

Instruments

Anthropometry and Physical Fitness Tests

Body height was measured to the nearest 0.1 cm using a stadiometer (Seca models 213 and 214; Seca GmbH, Hamburg, Germany) and body weight was measured to the nearest 0.1 kg on a calibrated digital balance (Seca models 861 and 877; Seca GmbH). The fitness test battery contained a progressive endurance run, trunk muscle strength test, standing long jump, seated shot put, and one-leg standing test. From those performance tests, a total fitness score was calculated (0–125 points).[12]

Body-Worn Sensors

Heart rate monitors (Suunto Smartbelt and Comfortbelt; Suunto, Vantaa, Finland) and combined step and acceleration monitors (GT1M [ActiGraph LLC, Fort Walton Beach, Florida] and PARTwear [HuCE microLab, Biel, Switzerland]) were

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used to register data for physical activity-related parameters. PARTwear is a self-produced device measuring accelerations and steps comparable to ActiGraph GT1M. Acceleration monitors were placed in belt pouches worn on the hip above the right anterior axillary line and at the side strap of the personal backpack. The sensors were programed to store heart rate, hip acceleration, step counts, and backpack acceleration data at 2-second intervals. Body-fixed sensors had to be worn from the time trainees woke up in the morning until they went to bed in the evening.

Injury Log and Training Reports

Injuries were registered if a subject who sustained physical damage to his body visited the medical care center for this reason. Injuries were continuously recorded in the individuals' medical records by the medical staff. Acute injuries were defined as those happening as a result of a sudden traumatic event. Overuse injuries were defined as those associated with repetitive physical activities. Duration and participation of sport-related PT lessons were registered after each session and reported on Saturday of the actual training week by the responsible PT supervisor. The school commander's military training reports were used to determine the duration of night rest.

Data Processing

Ambulatory Physical Activities and Demands Based on Body-Worn Sensor Data

For each training school and each investigated day of BMT, the median of volunteers' DOF, minutes spent in the military-specific activity classes, and physical PAEE were calculated. Therefore, heart rate, hip acceleration, backpack acceleration, and step frequency data were synchronized for each volunteer, and data were processed by using the algorithms presented in previous studies.[10,11] First, sensor data were used for the recognition of physically demanding, military-specific activities.[10] The assigned military-specific activity classes included walking, marching with a backpack, running, and MHA (lifting, carrying, digging). On the basis of activity recognition and sensor data, PAEE was estimated at 1-minute intervals.[11] Total energy expenditure (TEE) values were calculated as the sum of PAEE and resting energy expenditure (REE). REE was determined using anthropometric data applied to the formula for males by Mifflin et al.[13] The activity class "inactivity" was assigned if PAEE values were below 34.9 J/kg/min (TEE below 1.5 metabolic equivalent) based on the compendium of physical activity intensity of Ainsworth et al.[14,15] Step count data were used to estimate DOF in 1-minute intervals, according to the algorithm developed in Wyss et al.[16] To quantify the development of physical demands during the first 10 weeks of BMT, the regression coefficients (B) values of the two following linear regressions were calculated: independent predictor variable = "training week", and dependent variables = "DOF per week" and "PAEE per week." Monotony in physical demands for each training week was calculated according to Foster: "mean PAEE per week" divided by "standard deviation (SD) of PAEE per week."[17]

Injury Incidence

The injury incidence rate was expressed as the total number of registered injuries per 100 recruits per month. Injury incidence proportion was calculated as the number of recruits with one or more injuries during 18 weeks of military service divided by the total number of assessed recruits.

Statistical Analysis

Statistical analyses were performed using SPSS for Windows (version 20.0, IBM, Chicago, Illinois) with an alpha level of 0.05 to indicate statistical significance. Group results are presented as mean ± SD. Multivariate linear regression analysis with stepwise backward elimination was used to detect risk factors for injury incidence. The dependent variable was the injury incidence rates of each military training school. The potential independent predicting variables listed in Table I were calculated for each of the 12 training schools. All variables had normal distribution, approximately. Therefore, Q–Q plots were visually analyzed and a Shapiro–Wilk test was performed ($p > 0.05$). All potential predicting variables were tested for multicollinearity using Pearson's correlation coefficient. On the basis of these results, the number of predicting variables in the multiple linear regression model were reduced to maximally eight independent predicting variables. To compare the injury prevention power of different predicting variables, each B value of the final multiple linear regression model was multiplied with the SD of respective data (Table IV). Further, the effect size of these predicting variables was calculated according to Cohen[18] as

$$f^2 = \frac{\left(R^2_{\text{including}} - R^2_{\text{excluding}}\right)}{1 - R^2_{\text{including}}}.$$

Representativeness of the subgroups of 50 volunteers wearing sensors in each training school was investigated. Using Student's t test, these volunteers' age, body mass index

TABLE I. Potential Risk Factors for Injury Incidence

Independent Variables as Potential Independent Predicting Variables
Mean PAEE (MJ/d)
Mean DOF (km/d)
Development of PAEE During First 10 Weeks of BMT (ΔMJ/week)
Development of DOF During First 10 Weeks of BMT (Δkm/week)
Monotony (index)
Mean Time Spent With Physically Demanding MHA (min/d)
Mean Time Doing Sport-Related PT (min/week)
Mean Time Being Inactive (h/d)
Mean Night Rest (h/d)
Initial Fitness Level (score)
Initial Body Mass Index BMI (kg/m^2)

(BMI), and fitness level were compared to all volunteers in the specific training school.

RESULTS

A total of 1,676 recruits in the 12 selected military training schools volunteered for this study. Volunteers were 20.7 ± 1.2 years old, had a body height of 177.6 ± 6.3 cm, a body mass of 73.7 ± 10.6 kg, and therefore a BMI of 23.4 ± 3.0 kg/m^2. Furthermore, an initial physical fitness performances of 73.5 ± 12.2 score points based on a distance in seated shot put of 6.4 ± 0.7 m, a standing long jump of 2.3 ± 0.2 m, a one leg standing test performance of 48.8 ± 12.7 seconds, a trunk muscle strength test performance of 137.7 ± 60.1 seconds, and a progressive endurance run time of 787.3 ± 199.5 seconds was measured before the volunteers' military service. The mean values for each training school and the respective injury incidence rates and injury incidence proportions are shown in Table II. On average, 54.1 ± 5.5% of the recruits visited the medical care center at least once during their BMT due to injury. For acute injures, the injury incidence proportion was 28.7 ± 8.0%; for overuse injuries, it was 36.0 ± 6.3%. The average injury incidence rate was 18.0 ± 2.8 injuries per 100 recruits per month, 7.7 ± 2.2 acute injuries per 100 recruits per month, and 10.3 ± 2.8 overuse injuries per 100 recruits per month (Table II).

The 50 volunteers chosen to wear body-fixed sensors in each of the 12 training schools were shown to be representative of all recruits in their study group. They did not differ in age, BMI, or fitness level from the total group of volunteers in each training school ($p \geq 0.10$). Of a total of 600 volunteers wearing body-fixed sensors, 58 volunteers (9.7%) did not provide sensor data because they were excluded from the BMT during the first week of their military service. As volunteer involvement was low on Fridays, only data collected from Mondays to Thursdays were included in the analysis. Sensor data of 60.3 ± 13.0% from the assigned volunteers were used for the analysis of each of the remaining week days. The data of the other 39.7% of volunteers were excluded either because participants did not wear the sensors (60% of data loss) or due to technical problems or mechanical defects of the sensors (40% of data loss).

Physical Training Patterns in 12 Swiss Army BMT Schools

Recruits had a daily PAEE of 11.0 ± 1.4 MJ (TEE of 18.3 ± 1.4 MJ), they covered 14.0 ± 2.1 km/day on foot. They spent 37.9 ± 14.5 min/day with MHA and 112.0 ± 47.1 min/week doing sport-related PT. For recreation, recruits got an average of 7.0 ± 0.4 hours of night rest and 2.0 ± 0.6 hours of inactivity during the day. The development of physical demands during the first 10 weeks of BMT was found to be heterogeneous within the 12 investigated training formations. On average, a decrease of −0.4 ± 1.7 MJ/week, and −1.7 ± 1.9 km/week was observed.

Multivariate Linear Regression to Relate Training Patterns to Incidence of Injuries

Of all independent variables listed in Table I, the variables "DOF," "development of PAEE values in the first 10 weeks of BMT," and "inactivity" were excluded from the model due to multicollinearity to remaining variables (r = 0.589–0.773, $p < 0.05$). The final multiple linear regression model showed that high physical demands (PAEE values as well as time spent on MHA), decreasing development of DOF, low monotony in weekly physical demands, little time spent on sport-related PT, and little time for night rest were significant risk factors for injuries. Together, those variables describe 98.8% of the variances ($R^2 = 0.995$, adjusted $R^2 = 0.988$, $F = 155.2$, $MS_M = 14.7$, $MS_R = 0.1$, $p < 0.001$) of total injury incidence rate between military training schools (Table III). The effect size was large for all included predictor variables from $f^2 = 2.7$ for physically demanding materials handling up to $f^2 = 29.0$ and 33.6 for development of DOF and average PAEE.

The effects of a change of 1 SD in each risk factor on injury incidence are presented in Table IV. Therefore, B values of the regression model shown in Table III are multiplied with SD values. Results show that if all risk factors

TABLE II. Mean Age, Body Mass Index (BMI), and Fitness Score Prior to Military Service and Injury Rates During 18 Weeks of BMT of 1,676 Volunteers in 12 Swiss Army BMT Schools

Training School	N	Age (years)	BMI (kg/m^2)	Fitness (score)	Injuries (per 100/month)	Acute Injuries (per 100/month)	Overuse Injuries (per 100/month)
A	131	20.8 ± 1.4	23.7 ± 3.2	70.1 ± 13.4	12.2	7.1	5.1
B	145	20.7 ± 0.9	23.1 ± 2.1	87.2 ± 7.2	18.2	7.4	10.8
C	76	20.8 ± 1.1	22.3 ± 2.2	89.0 ± 11.2	18.7	5.3	13.5
D	107	20.9 ± 1.1	23.8 ± 3.6	75.8 ± 13.8	18.3	5.2	13.1
E	134	20.6 ± 1.4	23.5 ± 3.2	72.1 ± 14.3	21.1	7.8	13.3
F	150	21.0 ± 1.1	23.4 ± 2.6	73.4 ± 10.7	16.2	5.8	10.5
G	158	20.4 ± 1.1	23.2 ± 2.6	74.1 ± 11.8	16.7	5.9	10.8
H	156	20.6 ± 1.3	23.6 ± 2.7	65.9 ± 13.9	21.5	8.6	12.9
I	112	20.5 ± 1.3	22.7 ± 2.8	70.8 ± 11.1	21.3	10.9	10.4
J	163	20.5 ± 1.3	23.2 ± 3.6	69.8 ± 12.7	14.3	7.0	7.2
K	165	20.8 ± 1.3	23.6 ± 3.3	70.4 ± 12.0	19.9	11.9	8.0
L	179	20.5 ± 1.1	24.1 ± 3.2	72.4 ± 13.5	17.4	9.8	7.6

TABLE III. Multiple Linear Regression Model to Predict Injury Incidence in BMT (Injuries/100 Recruits/Month)

Predictor variable	B	SE B	β	t	p
Constant	60.887	3.544		17.182	0.000
PAEE (MJ/d)	1.446	0.123	0.718	11.763	0.000
Development DOF (Δkm/week)	−1.162	0.072	−0.761	−16.141	0.000
Monotony (index)	−3.591	0.171	−1.240	−20.949	0.000
Physical Training (min/week)	−0.053	0.004	−0.882	−13.447	0.000
Night Rest (h/d)	−5.382	0.386	−0.720	−13.955	0.000
PD Materials Handling (min/d)	0.036	0.009	0.185	4.177	0.009

PD, physically demanding.

would change about 1 SD for the better, the total injury incidence rate would be reduced by 72.4%.

For acute injuries, high PAEE values (p = 0.004), low sport-related PT participation (p = 0.012), little night rest (p = 0.021), and little monotony (p = 0.041) remained as risk factors in the model. Together, those variables described 60.5% (R^2 = 0.749, adjusted R^2 = 0.605, F = 5.2, p < 0.029) of acute injures. For overuse injuries, resulting decreasing distances covered on foot from week to week (p < 0.001), little monotony (p = 0.002), and time spent with physically demanding MHA (p = 0.020) were risk factors. Those variables predicted 83.5% (R^2 = 0.880, adjusted R^2 = 0.835, F = 19.6, p < 0.001) of the variance in overuse injuries between the investigated training schools.

DISCUSSION

The Problem of High Numbers of Injury Incidences in the Swiss Army BMT

In the 12 BMT schools investigated in this study, an average injury incidence rate of 18.0 injuries per 100 recruits per month was investigated (Table II). The meta-analysis of studies in different nations' armed forces from Kaufman et al[19] and additional studies[20,21] calculated injury incidence rates ranging from 10 to 15 per 100 recruits per month in male recruits. Based on statistics from Swiss military insurance,[22] the average injury case in Swiss Army militia members in 2011 incurred medical costs of 1,750 Swiss Francs (1,925 USD, 1.0 CHF = 1.1 USD, January 2013). Therefore, the difference in injury incidence rates between the upper range of comparative values (15 injuries/100 recruits/month) and average injury rates in the Swiss Army BMT (18 injuries/100 recruits/month) incurred additional medical costs of about 6.9 million Swiss Francs (about 7.6 million USD) for 25,000 recruits per year. The outlined differences between injury incidences in this study compared to the literature may be the result of diverse causes. Differences in the kind of armed forces (the Swiss Army is compulsory), materials, physical capabilities of the trainees, access and inhibition threshold to visit the medical care center, and differences in PT programs may cause this diversity. As Kaufman et al[19] stated, high musculoskeletal injury rates occur mainly as a result of military PT. Therefore, the comparison of PT patterns in Swiss Army BMT and BMT in other nations may explain the differences in injury incidence rates.

Impact of Training Patterns on Injury Incidences

Energy Expenditure

In this study, different variables were investigated to describe PT patterns in 12 BMT schools. The relationship of each variable to injury risk and a comparison of each variable to data from other nations' military organizations, are discussed. The first variable discussed is energy expenditure. High average PAEE values have been shown to be a risk factor for injuries (Table III). Therefore, this study reconfirmed prior results,[23,24] demonstrating that high physical demands during daily military routine are significant risk factors for high injury incidences. However, average TEE values assessed in Swiss Army BMT (18.3 MJ/day) were similar to values (17–18 MJ/day) assessed for various other nations' BMT formations of comparable duration.[25–27]

TABLE IV. Effects on Injury Incidence by Changes in Predictor Variables About 1 SD Each Based on the Linear Regression Model Shown in Table III

Predictor Variable	Mean	SD	Injury Incidence Reduction (ΔI/100/Month)	Ratio of Reduced Injuries (%)
PAEE([MJ/d)	11.0 MJ/d	−1.4 MJ/d	−2.04	−11.3
Development DOF (Δkm/week)	−1.7 Δkm/week	1.9 Δkm/week	−2.23	−12.4
Monotony (Index)	5.2 Index	1.0 Index	−3.53	−19.6
Physical Training (min/week)	112.0 min/week	47.1 min/week	−2.57	−14.3
Night Rest (h/d)	7.0 h/d	0.4 h/d	−2.15	−11.9
PD Materials Handling (min/d)	37.9 min/d	−14.5 min/d	−0.52	−2.9

Mean and standard deviation (SD) were calculated using average values for each of 12 training schools. PAEE, physical activity energy expenditure; DOF, distance covered on foot; PD, physically demanding.

Distance Covered on Foot

DOF was not included as an independent variable in the multiple linear regression model to predict injury incidence due to multicollinearity. DOF was strongly correlated to PAEE. However, based on results of other studies,[23,24,28,29] DOF is also related to injury risk. The average DOF by Swiss recruits (14.0 km/day, range of 11–18 km/day) was on the upper range or even greater than comparative data of trainees in the U.S. Army BMT (12 km/day, range of 10–14 km/day).[30] Unfortunately, to the author's knowledge, no data on DOF in the armed forces of other nations have as yet been published.

Development of PAEE and DOF During First 10 Weeks of BMT

Results demonstrated that physical demands on Swiss Army recruits are high during the first weeks and thereafter decreased in 9 out of 12 Swiss Army BMT schools investigated. The average DOF decreased in the first 10 weeks of BMT by −1.7 km/week. That training pattern of decreasing development of distances covered on foot has shown to be an important injury risk factor (Table III). Compared to the armed forces of other nations, the problem of the lack of a progressive loading at the beginning of BMT seems to be considerably large in the Swiss Army. In British Army Parachute Regiment recruits' energy expenditure, activity counts, and relative heart rate values did not change from week 1 to week 9 of BMT.[27] In U.S. Army BMT, a commendable progressive development of distances covered on foot from week 3 to week 12 was demonstrated.[31]

Monotony

A further variable that describes training patterns is monotony in weekly training demands. High monotony was shown to be an injury risk factor in elite sports.[9,17] In this study, the opposite was detected in a military setting: the more alike PAEE values from each training day per week were, the lower the injury risk was. Almeida et al[23] came to a similar conclusion: abrupt increases in training volume may contribute to injury risk in a military setting. Although PAEE values during daily routine are comparable between military trainees and athletes,[16] habituation to PT demands is an important difference. It is probable that a daily routine with high monotony is easier to cope with for recruits who are not habituated to the high PT demands. On the other hand, for athletes who have been participating in regular PT for years, monotony can promote overuse injuries.

Physically Demanding Materials Handling

The present data and prior studies[32] show that the amount of time trainees spend on MHA is also related to injuries. Unfortunately, no recent comparative data to quantify MHA during daily military routine from other nations' military organizations is available. However, many studies concluded that materials handling activities are the most frequent and therefore the most relevant physical requirement of all physically demanding tasks in military occupations.[3,32]

Sport-Related PT

The injury risk during PT and sport sessions is higher than most other activities during the daily routine.[33,34] However, the enhanced risk during PT might be compensated by reduced injury risk during the rest of the military daily routine. Results of this study demonstrate that an increase in time spent in sport-related PT activities decreases the risk of injuries in BMT. That preventive effect may be due to the enhanced physical fitness and motor control developed through sport-related PT lessons.[35,36] The main content of sport-related PT sessions in the Swiss Army consists of strength and aerobic fitness training, team sport, obstacle courses, fitness tests, and orienteering.[35] However, investigated Swiss Army recruits got only an average of 112 minutes of sport-related PT in 1.3 training sessions per week, with a large variety between training schools (20–181 min/week). The average of 112 minutes seems to be less than the BMT in other countries. Among U.S. Army recruits, 227 minutes PT in 3.8 training sessions per week was observed[37]; among recruits in the U.K. BMT, 284 minutes of PT per week was observed[38]; recruits in Singapore Armed Forces have 240 minutes of PT per week[39]; and Norwegian infantry recruits have 120 minutes of PT per week.[40]

Night Rest

The amount of time trainees got to rest during the night was negatively related to injury risk: the more night rest, the lower the injury risk. Investigated Swiss Army trainees got an average night rest (bed time) of 7 hours. However, 7 hours of bed time are estimated to equal approximately 6.5 hours of sleep per night.[41] No comparative data with other nations' BMT was found. However, Belenky at al[41] demonstrated that 8 hours of night rest are needed in a military setting. Even 1 hour less (7 hours of bed time) showed a small but immediate decline in cognitive performance in their study.[41,42] Because mental fatigue and impaired physical performance are strongly related,[43] the recommendation of 8 hours of night rest in a military setting is also relevant for injury prevention.

Implications for Injury Prevention

For injury prevention, modifications of the variables listed above shall be considered (Table IV). The first variable in the table, PAEE, represents the total amount of physical activities and demands during BMT. The fewer the physical activities recruits have to perform during BMT, the lower their overall risk of injury. The second variable is called development of DOF. It represents changes in the weekly total walking, marching, and running distances. If DOF is low at the beginning and increases thereafter during BMT, the overall risk of injury is reduced, compared to a decreasing development of DOF. The third variable, monotony, represents changes in physical demands during 1 week. If physical activities and demands are similar for each weekday, monotony is high, and injury incidents are fewer, compared to a situation with large differences between daily physical demands. A further variable in the present model is physically demanding MHA, representing time spent on activities like digging, lifting loads and carrying loads. The less often recruits work with heavy equipment, the fewer injury incidents are registered. The fifth variable is PT, which represents time spent on sports and PT sessions (mostly strength and aerobic fitness training or team sports). The more time recruits spend on PT sessions, the lower is their overall injury risk. The last variable in the present model is night rest. With an increased amount of sleep at night, a decrease in injury incidence is expected.

Not every variable can be easily modified without significantly disrupting the actual content of the military training program. The authors of this study suggest three variables, the modifications of which will not significantly disturb the military training program, but will offer positive effects in terms of injury prevention: Reduction of marching and running distances in the first 4 weeks and promotion of a progressive development of DOF during the following weeks of BMT; conducting at least 3 hours of PT per week; and providing a night rest of 8 hours on normal training days. In two of those variables (development of physical demands during BMT and quantity of PT), the data from Swiss Army training schools were different from that published on comparative BMT of other nations' military organizations. An adjustment of the two variables to the levels found in other military organizations would reduce injury incidence rates in Swiss Army BMT. Based on the present regression model, a constant development of DOF (0 km/week instead of −1.7 km/week) in the first 10 weeks of BMT and a total volume of 180 minutes instead of only 112 minutes of PT per week would result in an average total injury incidence of 12.4 instead of 18.0 injuries per 100 trainees per month (Tables III and IV). Therefore, the modification of the two variables would lower the injury incidence rates in Swiss Army BMT to rates comparable with other nations' military organizations.

Limitations

A limitation of this study is the lack of comparative data from other nations' military organizations for some of the investigated variables. Because of financial constraints, it was not possible to equip each volunteer with body wearable sensors. However, each subgroup of 50 volunteers chosen to wear the sensors was representative of its respective group of recruits in the specific training school. Another limitation of this study is that many volunteers removed their sensors before bed time on Fridays. Therefore, only data collected on Mondays to Thursdays were included in the data analysis in this study. For each investigated training day, a data loss of 40 ± 13% of sensor data resulted. A data loss to that extent is not unexpected, since an attrition rate of 10% of recruits is common in the Swiss Army, some recruits do miss training days due to illness or injuries, and sensors worn by physically active recruits can acquire mechanical defects. However, since all recruits in each training school undergo the same military training, that data loss does not violate generalizability.

CONCLUSION

The new method used in this study adequately describes PT demands in a military setting. The feasibility of measuring physical activities and demands using body-worn sensors in larger groups of subjects was good, and a high number of different training patterns could be measured without the need for time-consuming in situ observations or subjective self-report questionnaires. The method used to objectively assess training demands allowed this study to investigate the impact of training patterns on injury incidence in a large number of different training schools.

High injury incidences (18.0 injuries per 100 recruits per month) are a serious problem in Swiss Army BMT. The multiple linear regression model showed that high physical demands (PAEE values and time spent on physically demanding material handling), decreasing distances covered on foot, low monotony in weekly physical demands, little time spent in sport-related PT, and little time for night rest are significant risk factors for injuries. Together, those variables describe 98.8% of the variances of total injury incidence rates in military training schools. The presented results offer important information for future interventions to reduce injury incidence rates in a military setting.

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