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ROZPRAWA DOKTORSKA

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Poziom wybranych funkcji wykonawczych a wyszkolenie bojowe i osiągnięcia akademickie kobiet i mężczyzn – podchorążych Akademii Wojsk Lądowych we Wrocławiu

Level of selected executive functions in relation to combat training and academic achievements of male and female cadets of the Military University of Land Forces in Wroclaw

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Spis treści

Podziękowania

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1. Wskazanie osiągnięć

1.1. Tytuł osiągnięcia naukowego

Jako dorobek naukowy, będący podstawą złożonego wniosku o wszczęcie postępowania w sprawie nadania stopnia naukowego doktora nauk o kulturze fizycznej, wskazuję cykl publikacji naukowych, w skład których wchodzi 3 artykuły prezentujące tematykę moich badań pod wspólnym tytułem:

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1.2. Wykaz publikacji zawartych w osiągnięciu naukowym

Zaprezentowany cykl prac naukowych został przedstawiony w kolejności od publikacji najstarszej do najnowszej:

1. Jamro, D.; Zurek, G.; Lachowicz, M.; Lenart, D. Influence of Physical Fitness and Attention Level on Academic Achievements of Female and Male Military Academy Cadets in Poland. Healthcare (Basel) 2021, 9 (10), 1261.
   Doi: 10.3390/healthcare9101261. MEiN: 40, IF: 3.160.
2. Jamro, D.; Zurek, G.; Lachowicz, M.; Lenart, D.; Dulnik, M. Alternating Attention and Physical Fitness in Relation to the Level of Combat Training. Healthcare (Basel) 2022, 10 (2), 241.
   Doi: 10.3390/healthcare10020241. MEiN: 40, IF: 3.160.
3. Jamro, D.; Zurek, G.; Dulnik, M.; Lachowicz, M.; Lenart, D. Executive Function Level in Cadets' Shooting Performance. International Journal of Environmental Research and Public Health 2022, 19 (10), 6007.
   Doi: 10.3390/ijerph19106007. MEiN: 140, IF: 4.614.

Łączna liczba uzyskanych punktów Ministerstwa Edukacji i Nauki wynosi 220, natomiast współczynnik IF dla całego cyklu wynosi 10.934. Poszczególne artykuły wchodzące w skład osiągnięcia naukowego zostały zamieszczone w pełnych wersjach w rozdziale **IX**.

Mój wkład w przygotowanie każdej publikacji obejmował: planowanie projektu, pozyskanie środków finansowych, opracowywanie metodologii, przeprowadzenie badań, przygotowywanie pierwotnej wersji tekstów, redagowaniu manuskryptów po otrzymanych recenzjach oraz tworzenie ostatecznej wersji, gotowej do opublikowania.

1.3. Wykaz pozostałych artykułów

1) Jamro, D.; Lenart, D.; Żurek, G. Physical fitness of candidates to the General Tadeusz Kościuszko Military University of Land Forces. SJMULF. 2021, 202 (4): 652-663. 10.5604/01.3001.0015.6171

MEiN: 20

2) Żurek, G., Lenart, D., Lachowicz, M., Żebrowski, K., Jamro, D. Factors Influencing the Executive Functions of Male and Female Cadets. Int. J. Environ. Res. Public Health. 2022, 19 (24): 17043. 10.3390/ijerph192417043

MEiN: 140, IF: 4.614

1.4. Wykaz konferencji naukowych (aktywny udział)

1) V Ogólnopolska Konferencja dla Młodych Naukowców – „Wieczór Naukowca 2022 – Wokół Człowieka". Temat wystąpienia: Poziom funkcji wykonawczych i osiągnięć akademickich a sprawność fizyczna podchorążych Akademii Wojsk Lądowych we Wrocławiu. Wrocław, 08.06.2022 r.
2) Lachowicz, M., Żurek, G., Dulnik, M., Jamro, D. Konferencja naukowa Życie w Wirtualnej Rzeczywistości – Aspekty Ekonomiczne, Pedagogiczne, Psychologiczne i Prawne. Temat wystąpienia: Evaluation of changes in students' stress tolerance under the influence of virtual reality. Radom, 08–09.04.2022 r.

1.5. Wykaz konferencji naukowych (współorganizacja)

1) XII Ogólnopolska Konferencja Naukowa „Kultura fizyczna w służbach mundurowych – wczoraj – dziś – jutro". Poznań, 27.10.2022 r.

1.6. Wykaz nagród

1) Wyróżnienie za najlepszą wygłoszoną pracę (sesja VARIA) podczas V Ogólnopolskiej Konferencji dla Młodych Naukowców – „Wieczór Naukowca 2022 – Wokół Człowieka". Temat wystąpienia: Poziom funkcji wykonawczych i osiągnięć akademickich a sprawność fizyczna podchorążych Akademii Wojsk Lądowych we Wrocławiu. Wrocław, 08.06.2022 r.

2. Streszczenie

Słowa kluczowe: funkcje poznawcze, wyszkolenie bojowe, osiągnięcia akademickie, różnice międzypłciowe, podchorążowie.

Wstęp. Głównymi czynnikami świadczącymi o wyszkoleniu bojowym współczesnego żołnierza są jego sprawność fizyczna oraz umiejętności strzeleckie. Jednocześnie w wymagającej służbie wojskowej, a w szczególności na stanowiskach dowódczych ważnym aspektem jest wysoki poziom funkcji wykonawczych, przyczyniający się do efektywnej realizacji wymagających zadań służbowych. Z uwagi na zmiany w strukturze szkolenia oraz rosnącej obecności kobiet w wojsku zagadnienie to dotyczy zarówno mężczyzn jak i kobiet, które stopniowo zaczynają odgrywać większą rolę w służbie wojskowej.

Cel. Celem badań było poszukiwanie związków pomiędzy poziomem sprawności fizycznej, funkcjami wykonawczymi, osiągnięciami akademickimi oraz poziomem wyszkolenia bojowego podchorążych a także zbadanie różnic międzypłciowych w poziomie tych zmiennych wśród podchorążych Akademii Wojsk Lądowych we Wrocławiu (AWL).

Grupa badanych. Grupę badanych stanowili studenci (podchorążowie) AWL – kandydaci na żołnierzy zawodowych. Dane zbierane były od lutego 2021 r. do lutego 2022 r. Badaniami zostali objęci podchorążowie, którzy w 2020 roku rozpoczęli jednolite wojskowe studia magisterskie na kierunku dowodzenie tj. 228 podchorążych, w tym 31 kobiet i 197 mężczyzn w wieku 19–25 lat. Wśród grupy badanych dokonano analizy sprawności fizycznej, zbadano poziom funkcji wykonawczych oraz ich sprawność strzelecką i osiągnięcia akademickie.

Metody badawcze. W celu określenia poziomu sprawności fizycznej zostały przeprowadzone pomiary oraz próby poszczególnych komponentów sprawności fizycznej wg. koncepcji Health-Related-Fitness (H-RF) (Howley i Franks, 1992):

1. Komponenty morfologiczne:
   - wysokość ciała,
   - masę ciała.

Ponadto wyliczono wskaźnik masy ciała BMI (body mass index) wg. wzoru:

$$BMI = \frac{\text{Masa ciała [kg]}}{\text{Wysokość ciała}^2\ [\text{m}^2]}$$

2. Do oceny komponentów motorycznych sprawności fizycznej użyto wybranych prób z powszechnie obowiązujących baterii testów, ocenie poddano następujące komponenty motoryczne:
   - siła statyczna,
   - szybkość,
   - wytrzymałość.
3. Procesy związane z uwagą oraz z wybranymi funkcjami wykonawczymi (utrzymania i przerzutności uwagi, celowego przeszukiwania materiału, sekwencyjnego przetwarzanie informacji oraz monitorowania własnego zachowania) zbadano przy użyciu Kolorowego Testu Połączeń w wersji dla dorosłych (ang. *Color Trail Test*).
4. Osiągnięcia w nauce określone zostały na podstawie semestralnych wyników akademickich (ocen) z przedmiotów:
   - cywilnych: humanistycznych i społecznych oraz ścisłych i przyrodniczych,
   - wojskowych: teoretycznych i praktycznych.

   Uwzględniona w badaniach ocena z danej grupy przedmiotów stanowiła średnią arytmetyczną ocen wchodzących w skład danej grupy osiągnięć akademickich.
5. Poziom wyszkolenia bojowego podchorążych oceniono na podstawie wyników osiągniętych ze szkolenia strzeleckiego oraz taktycznego.

Metody statystyczne. Zgromadzone wyniki poddano analizie statystycznej stosując, w zależności od potrzeb, następujące metody:

- normalność rozkładu sprawdzono przy pomocy testu Shapiro-Wilka oraz testu Kołmogorowa-Smirnowa;
- obliczono wartości średnie, odchylenia standardowe (SD) oraz współczynniki zmienności (v);
- istotność różnic między dwoma średnimi obliczono za pomocą testu U Manna--Withneya dla prób niezależnych oraz testem t-Studenta dla prób niezależnych;
- w celu określenia istotności statystycznej różnic pomiędzy badanymi zmiennymi przeprowadzona została analiza wariancji dla klasyfikacji jednoczynnikowej ANOVA; porównania wielokrotne post-hoc testem NIR (najmniejszych istotnych różnic);

- związki między badanymi zmiennymi oceniono za pomocą korelacji Spearmana oraz Pearsona;
- celem utworzenia równania służącego do oszacowania wartości zmiennej wyjaśnianej dokonano analizy za pomocą regresji krokowej postępującej oraz regresji optymalnej, metodą najlepszego podzbioru. Pozwoliło to wyznaczyć optymalny zbiór zmiennych wyjaśniających.

Istotność statystyczna w pracy, w przypadku wszystkich zastosowanych testów przyjęta została na poziomie $p < 0,05$. Obliczenia wykonano w programie Statistica v. 13 (StatSoft, Tulsa, OK, USA) w Pracowni Badań Biostruktury Akademii Wychowania Fizycznego we Wrocławiu, posiadającej certyfikat ISO 9001.

Wyniki

1. Nie ujawniły się istotne różnice międzypłciowe w poziomie uwagi i funkcji wykonawczych wśród podchorążych.
2. Spośród analizowanych **osiągnięć akademickich** kobiety uzyskiwały istotnie wyższe wyniki w nauce z przedmiotów cywilnych (ścisłych i przyrodniczych) natomiast mężczyźni osiągali znacznie wyższe oceny z przedmiotów wojskowych (praktycznych).
3. W wynikach dotyczących **analizy prostych zależności** między uwzględnionymi zmiennymi somatycznymi i motorycznymi, poziomem uwagi a osiągnięciami akademickimi w **grupie kobiet**: osiągnięcia z przedmiotów cywilnych (humanistycznych i społecznych) oraz wyniki testu CTT-1 okazały się być pozytywnie skorelowane z siłą ręki dominującej. Osiągnięcia z przedmiotów cywilnych (ścisłych i przyrodniczych) korelowały dodatnio z masą ciała, wskaźnikiem masy ciała BMI oraz z siłą ścisku ręki dominującej. W **grupie mężczyzn** w stwierdzone korelacje między zmiennymi były słabe i sporadyczne.
4. W odniesieniu do **determinantów osiągnięć akademickich** podchorążych, wyniki analizy regresji pokazały, że w **grupie kobiet** siła ręki dominującej ma największy wpływ na wyniki w nauce z przedmiotów cywilnych oraz wojskowych (teoretycznych), wyniki te w tym obszarze są tożsame z analizą prostych korelacji w grupie kobiet. W tym przypadku siła ręki dominującej jest silnym uwarunkowaniem osiągnięć akademickich z przedmiotów cywilnych oraz wojskowych (teoretycznych), wyjaśniając wspólnie z testem uwagi CTT-1 39,9% zmienności wyników przedmiotów cywilnych (humanistycznych i społecznych), wspólnie z masą ciała oraz wysokością 50,8% zmienności wyników przedmiotów

cywilnych (ścisłych i przyrodniczych) oraz wspólnie z wskaźnikiem masy ciała BMI, masą ciała oraz wysokością 44,1% zmienności wyników przedmiotów wojskowych (teoretycznych). **W grupie mężczyzn** spośród analizowanych zmiennych nie ujawniły się istotne modele predykcji osiągnięć akademickich.

5. W badaniu **wyszkolenia bojowego**, wyższe wyniki strzeleckie w grupie mężczyzn silnie powiązane były z wyższym poziomem przerzutności uwagi (r = 0,57). Znacząco wyższe osiągnięcia akademickie z praktycznych przedmiotów wojskowych związane były z większym poziomem siły oraz lepszą wytrzymałością kadetów. Siła tych korelacji była jednak słaba.
6. Poziom przerzutności uwagi, ujawnił się jako silnym determinant celności strzelania w grupie mężczyzn, który istotnie wyjaśniał 31,5% zmienności wyników strzeleckich podchorążych (skorygowane $R^2 = 0,315$).
7. Nie ujawniły się istotne różnice między kobietami i mężczyznami w poziomie sprawności strzeleckiej z poszczególnych strzelań.
8. W grupie kobiet wyższe wyniki strzeleckie z pistoletu wojskowego były znacząco związane z wyższym poziomem funkcji wykonawczych (r = -0,76).
9. Wyniki korelacji ujawniły, że w grupie mężczyzn wyższe wyniki w strzelaniu były istotnie powiązane z krótszym czasem wykonywania CTT-2. Silne korelacje wystąpiły pomiędzy strzelaniem z karabinka (r = -0,47) i strzelaniem z pistoletu wojskowego (r = 0,51) a wynikami CTT-2. Zależność pomiędzy wynikami strzelania z pistoletu maszynowego a czasem CTT-2 była na poziomie przeciętnym (r = -0,39). Słaba, ale również istotna korelacja wystąpiła pomiędzy wynikami strzelania z karabinka w masce przeciwgazowej a czasem w CTT-2 (r = -0,18).

Wnioski:

1. Zasadne jest wprowadzenie do szkolenia strzeleckiego specjalistycznego treningu ukierunkowanego na rozwój funkcji wykonawczych takiego jak np. Strategy--Based Cognitive Training (Mowszowski i wsp., 2016), w szczególności we wstępnym procesie szkolenia strzeleckiego, gdzie pierwsze strzelania wykonuje się na celność i skupienie. Wiedza ta powinna szczególnie zainteresować badaczy ze środowiska służb mundurowych oraz te grupy zawodowe, w których broń jest podstawowym narzędziem pracy.

2. Wyniki badań wskazują, że podchorążowie – kobiety reprezentują podobny poziom funkcji wykonawczych jak i sprawności strzeleckiej, dlatego też nie powinno się różnicować obciążenia oraz sposobów oceny w szkoleniu ze względu na płeć.
3. W ramach rozwoju sprawności fizycznej podchorążych, główny nacisk powinien być kładziony nieprzerwanie na rozwój siły, szczególnie wśród kobiet. Siła bowiem okazała się być silnym determinantem osiągnięć akademickich z przedmiotów cywilnych i wojskowych (teoretycznych).

3. Abstract

Keywords: cognitive function, combat training, academic achievement, gender differences, cadets.

Introduction. The main factors indicating the combat training of the modern soldier are his physical fitness and shooting skills. At the same time, in demanding military service, especially in command positions, an important aspect is a high level of executive function, contributing to the effective implementation of demanding service tasks. Due to changes in the structure of training and the increasing presence of women in the military, this issue affects both men and women, who are gradually beginning to play a greater role in military service.

Objective. The study aimed to look for relationships between the level of physical fitness, executive functions, academic achievement, and the level of combat training of cadets and to examine gender differences in the level of these variables among cadets of the Military University of Land Forces in Wroclaw (MULF).

Study group. The study group consisted of MULF students (cadets) – candidates for professional soldiers. Data were collected from February 2021 to February 2022. The study included students who began their uniform military master's degree in command in 2020, i.e. 228 cadets, including 31 women and 197 men aged 19–25. Among the subjects, physical fitness was analyzed, the level of executive function was examined, and their shooting performance and academic achievement.

Research methods. In order to determine the level of physical fitness, measurements and tests of the various components of physical fitness according to the Health--Related-Fitness (H-RF) concept were conducted (Howley i Franks, 1992):

1. Morphological components:
   - Body height,
   - Body weight.

   In addition, BMI (body mass index) was calculated according to the formula:

$$BMI = \frac{\text{Body weight [kg]}}{\text{Body height}^2\ [\text{m}^2]}$$

2. To assess the motor components of physical fitness, selected tests from a common battery of tests were used, and the following motor components were assessed:
   - Static strength,

- Speed,
- Endurance.

3. Processes related to attention and selected executive functions (maintaining and alternating attention, intentional searching of material, sequential processing of information, and monitoring of one's behavior) were examined using the adult version of the Color Trail Test.
4. Academic achievements were determined on the basis of semester academic achievements (grades) in the subjects:
   - civilian: humanities and social sciences and science,
   - military: theoretical and practical.

   The grade in a given group of subjects included in the study was the arithmetic average of the grades included in a given group of academic achievements.
5. The level of combat training of cadets was assessed on the basis of the results achieved from shooting and tactical training.

Statistical methods. The collected results were subjected to statistical analysis using the following methods, as appropriate:

- normality of distribution was checked using the Shapiro-Wilk test and the Kolmogorov-Smirnov test;
- mean values, standard deviations (SD) and coefficients of variation (v) were calculated;
- the significance of differences between two averages was calculated using the Mann-Withney U test for independent samples and the Student's t-test for independent samples;
- in order to determine the statistical significance of differences between the study variables, an analysis of variance for one-factor classification ANOVA was performed; procedure of post-hoc multiple comparisons in the form of the NIR (least significant difference) test;
- relationships between study variables were assessed using Spearman and Pearson correlations;
- in order to create an equation for estimating the value of the explained variable, an analysis was carried out using stepwise progressive regression and optimal regression, using the best subset method. This made it possible to determine the optimal set of explanatory variables.

Statistical significance in the study, for all tests used, was taken at $p < 0.05$. Calculations were performed using Statistica v. 13 software (StatSoft, Tulsa, OK, USA) at the ISO 9001-certified Biostructure Research Laboratory of the Wroclaw University of Health and Sport Sciences.

Results

1. No significant gender differences in levels of attention and executive function were revealed among cadets.
2. Among the academic achievements analyzed, women scored significantly higher in civilian subjects (sciences and natural sciences), while men achieved significantly higher grades in military (practical) subjects.
3. In the results concerning the analysis of simple correlations between the considered somatic and motor variables, the level of attention and academic achievement in the women's group: achievement in civilian subjects (humanities and social sciences) and CTT-1 test scores appeared to be positively correlated with the strength of the dominant hand. Achievement in civilian subjects (sciences and natural sciences) correlated positively with body weight, BMI body mass index, and the strength of the dominant hand. In the male group, the correlations found between variables were weak and sporadic.
4. With regard to the determinants of cadets' academic achievement, the results of regression analysis showed that in the female group, the strength of the dominant hand has the greatest impact on academic performance in civilian and military (theoretical) subjects, these results in this area are the same as the analysis of simple correlations in the female group. In this case, the strength of the dominant hand is a strong determinant of academic performance in civilian and military (theoretical) subjects, explaining jointly with the CTT-1 attention test 39.9% of the variation in performance in civilian subjects (humanities and social sciences), jointly with body weight and height 50.8% of the variation in performance in civilian subjects (sciences and natural sciences), and jointly with the BMI body mass index, body weight, and height 44.1% of the variation in performance in military (theoretical) subjects. In the male group, among the variables analyzed, no significant predictive models of academic achievement were revealed.
5. In the study of combat training, higher shooting scores in the male group were strongly associated with higher levels of metastability of attention ($r = 0.57$).

Significantly higher academic achievement in practical military subjects was associated with higher levels of strength and better endurance in cadets. However, the strength of these correlations was weak.

6. The level of alternating attention, revealed itself as a strong determinant of shooting performance in the men's group, which significantly explained 31.5% of the variation in the cadets' shooting performance (adjusted $R^2 = 0.315$).
7. No significant differences were revealed between men and women in the level of shooting performance from individual shooting.
8. In the women's group, higher military pistol shooting scores were significantly associated with higher levels of executive function ($r = -0.76$).
9. Correlation results revealed that in the men's group, higher shooting scores were significantly associated with shorter CTT-2 performance time. strong correlations occurred between carbine shooting ($r = -0.47$) and military pistol shooting ($r = 0.51$) and CTT-2 scores. the correlation between machine gun shooting scores and CTT-2 time was at the average level ($r = -0.39$). A weak but also significant correlation occurred between the results of shooting a carbine with a gas mask and time in the CTT-2 ($r = -0.18$).

Conclusions:

1. It is reasonable to introduce into shooting training specialized training aimed at the development of executive functions such as Strategy-Based Cognitive Training[2], especially in the initial process of shooting training, where the first shooting is done on accuracy and focus. This knowledge should be of particular interest to researchers in the uniformed services community and those professional groups where guns are the primary tool of the job.
2. The results of the study indicate that female cadets represent a similar level of executive function as well as shooting performance, so the load and methods of evaluation in training should not be differentiated by gender.
3. Within the framework of the development of the physical fitness of cadets, the main emphasis should be continuously placed on the development of strength, especially among women. This is because strength has proven to be a strong determinant of academic achievements in civilian and military (theoretical) subjects.

4. Wprowadzenie do problematyki funkcji wykonawczych, wyszkolenia bojowego oraz osiągnięć akademickich

4.1. Funkcje wykonawcze jako kluczowy zestaw umiejętności poznawczych

Badania nad funkcjonowaniem poznawczym człowieka rozpoczęły się wraz z zauważeniem istotnych różnic indywidualnych w zakresie wykonywania zadań poznawczych, szczególnie czynności uważanych za wysoko cenione w naszym kręgu kulturowym. Już w Średniowieczu czynnikiem świadczącym o wysokiej inteligencji była umiejętność czytania i pisania. Współcześnie, problemy w zakresie tych podstawowych umiejętności świadczyć mogą co najwyżej o głębokich deficytach poznawczych. Liczy się natomiast jakość czytania i pisania, szybkość przyswajania informacji a w szczególności rozumienia trudniejszych treści. W psychologii różnic indywidualnych próbuje się dociekać jak funkcjonuje pamięć, uwaga i inne procesy poznawcze oraz jakie są jej determinanty. Sprowadza się to do oceny sposobu działania elementarnych operacji umysłowych (Nęcka, 1994).

Funkcje poznawcze odzwierciedlają zbiór umiejętności, dzięki którym człowiek jest w stanie poznawać rzeczywistość, orientować się w przestrzeni, przyswajać wiedzę oraz nieprzerwanie przetwarzać zdobywane informacje. Kształtowanie funkcji poznawczych to jeden z najważniejszych elementów zrównoważonego rozwoju człowieka. Zasadniczo w literaturze funkcje poznawcze kategoryzowane są na podstawowe (elementarne) oraz złożone. Elementarne funkcje poznawcze obejmują: uwagę, pamięć, funkcje wykonawcze oraz wzrokowo-przestrzenne, natomiast złożone procesy poznawcze to myślenie (przyczynowo-skutkowe, abstrakcyjne, twórcze i planowanie) a także funkcje językowe. Podstawowe procesy poznawcze należy postrzegać jako fundament złożonych procesów poznawczych (Bidzan-Bluma i Lipowska, 2018).

Funkcje wykonawcze (nazywane też kontrolą wykonawczą lub kontrolą poznawczą) to zbiór odgórnych procesów kontrolnych, których używamy głównie w sytuacji, gdy poleganie wyłącznie na swojej intuicji i wyuczonych zachowaniach jest niewystarczające lub niemożliwe (Diamond, 2013). Funkcje wykonawcze przyczyniają się do utrzymania zdrowia poznawczego, umysłowego (Diamond, 2005) jak również do zachowania wysokiego poziomu sprawności fizycznej (Miller i wsp.,

2011). Są również istotnym predykatorem osiągnięć szkolnych i akademickich (Borella i wsp., 2010), pomagają w karierze zawodowej (Bailey, 2007) i w realizacji codziennych obowiązków (Brown i Landgraf, 2010). Uogólniając funkcje wykonawcze zapewniają zrównoważony rozwój na płaszczyźnie socjalnej, psychologicznej oraz poznawczej (Diamond, 2013).

W literaturze przedmiotu istnieje ogólna zgoda, że wyróżniamy trzy główne składowe funkcji wykonawczych: hamowanie (kontrola hamowania, hamowanie behawioralne, selektywna uwaga i hamowanie poznawcze), pamięć roboczą i elastyczność poznawczą (zwaną również przesuwaniem zbiorów, elastycznością umysłową lub przesuwaniem zbiorów umysłowych), która ściśle związana jest z kreatywnością (Miyake i wsp., 2000). Kontrola hamowania powiązana jest ze wstrzymywaniem zachowań nieodpowiednich dla danego zadania. Dzięki niej jesteśmy w stanie rozpoznawać skuteczne zachowania ważne dla sukcesu w wykonaniu danej czynności, co przekłada się ostatecznie na bezpośrednie działanie w celu osiągnięcia pożądanych rezultatów (Verbruggen i Logan, 2008). Pamięć roboczą, można zdefiniować jako zbiór procesów, które służą do przechowywania i przetwarzania tymczasowych informacji oraz realizowania wymagających zadań poznawczy jak na przykład rozumienie języka, uczenie się, czy rozumowanie. Elastyczność poznawcza służy do obserwacji i poprawiania własnych zachowań podczas wykonywania różnych zadań w celu poprawiania błędów. Dzięki niej jesteśmy w stanie aktualizować swoją pamięć roboczą, aktualizować swoje zachowanie do zmieniających się warunków i nie popełniać tych samych błędów w przyszłości (Egner i Hirsch, 2005). Z wymienionych powyżej składowych zbudowane są funkcje wykonawcze wyższego rzędu, takie jak planowanie, rozumowanie i rozwiązywanie problemów (Collins i Koechlin, 2012).

Problematyka funkcji wykonawczych jest w kręgu zainteresowań naukowców z różnych środowisk, w tym również coraz częściej badania funkcji wykonawczych przeprowadza się pośród populacji wojskowych. W szczególności przeprowadza się badania nad zmiennymi potencjalnie powiązanymi z poziomem funkcji wykonawczych (Diamond, 2013). Dotyczy to zarówno zmiennych somatycznych np. masy ciała – otyłość związana jest ze spadkiem kontroli hamowania żołnierzy Stanów Zjednoczonych (Ja i wsp., 2021) jak i reakcji fizjologicznych (przewlekła ekspozycja na hipoksję na różnych wysokościach negatywnie wpływa na hamowanie reakcji żołnierzy (Wei i wsp., 2021)). Dowiedziono też, że stres bojowy wśród żołnierzy

zmniejsza aktywność śródmózgowia, co w głównej mierze powiązane jest ze znacznym pogorszaniem się procesów związanych z uwagą (van Wingen i wsp., 2012). Z drugiej strony specjalistyczny trening umożliwia żołnierzom zawodowym utrzymywanie większej kontroli nad własnymi myślami i emocjami co przekłada się w praktyce na większy spokój podczas sytuacji zagrożenia (Ćosić i wsp., 2012). Udowodniono również na podstawie ostatnich badań, że specyficzne ćwiczenia wojskowe pozytywnie wpływają na zmiany strukturalne w mózgach żołnierzy. Wyniki licznych badań jasno podkreśliły, że specjalnie zaprogramowany trening wojskowy pozytywnie wpływa na funkcje wykonawcze żołnierzy (Batouli i Saba, 2020). Powyższe doniesienia z literatury korespondują z badaniami własnymi w obszarze powiązań funkcji wykonawczych z sprawnością strzelecką oraz osiągnięciami akademickim podchorążych.

Stanowiska służbowe w jednostkach wojskowych, szczególnie w jednostkach operacyjnych i bojowych stawiają coraz większe wymagania zarówno w sferze fizycznej jak i psychicznej. Coraz liczniej zajmują je także kobiety. Dlatego też zrozumienie różnic międzypłciowych wśród żołnierzy na różnych płaszczyznach może znacznie podnieść efektywność szkolenia oraz lepiej zrozumieć mechanizmy odpowiedzialne za behawioralne różnice płciowe.

Badania nad różnicami płciowymi w funkcjach wykonawczych dostarczają niejednoznacznych wyników. Podczas gdy, mężczyźni zwykle osiągaj lepsze wyniki w zadaniach przestrzennych (Maeda i Yoon, 2013) to w innych już nie, jak np. w testach badających kontrolę hamowania oraz pamięć operacyjną (Li i wsp., 2009). Natomiast Gaillard i wsp. (2021) w przeglądzie systematycznym badań w których zastosowano zaawansowane techniki neuroobrazowania do oceny różnic międzypłciowych w funkcjach wykonawczych postawili wniosek, że ciągle nie można wskazać na dokładne różnice między kobietami i mężczyznami w funkcjach wykonawczych. Głównym argumentem przemawiającym za tym wnioskiem jest fakt, że w badaniach stosuje się często dużą zmienność metodologiczną, dodatkowo mamy do czynienia z zaangażowaniem wielu sieci neuronalnych. Udowodniono natomiast, że kobiety i mężczyźni różnią się pod względem stosowanej strategii neuronalnej podczas wykonywania tych samych zadań poznawczych (Gaillard i wsp., 2021).

4.2. Metody badań niektórych funkcji wykonawczych

Funkcje poznawcze badać można przy użyciu różnych testów oraz technik badawczych. Za najnowszą i najwszechstronniejszą baterie testów do pomiarów funkcjonowania poznawczego uważa się obecnie NAB (*Neuropsychological Assessment Battery*) (Marder i wsp., 2004). Popularne testy do których zaliczają się m. in. WCST (Wisconsin Card Sorting Test), testu Stroopa oraz Kolorowy Test Połączeń CTT (*Color Trails Test*) stanowią ciągle główne narzędzia diagnostyczne zaburzeń związanych z pracą płatów czołowych. Ukierunkowane są one głównie na ocenę pamięci operacyjnej oraz funkcji wykonawczych. Powodem stosowania testów tzw. papier-ołówek, do których zalicza się CTT, jest prostota ich użycia oraz niskie koszty (Mosiołek, 2015). Obecnie istnieją również możliwości do oceny funkcjonowania poznawczego przy użyciu metod neurofizjologicznych oraz zyskujących na popularności w literaturze badań przy użyciu zaawansowanych technologicznie metod neuroobrazowania (Mosiołek i Łoza, 2004). CTT służy do badania różnorodnych procesów związanych z funkcjami wykonawczymi, a w szczególności do oceny celowego przeszukiwania materiału, utrzymania i przerzutności uwagi, sekwencyjnego przetwarzanie informacji oraz monitorowania własnego zachowania (D'Elia i wsp., 1996).

4.3. Funkcje wykonawcze a wyszkolenie bojowe i osiągnięcia akademickie podchorążych

Literatura na temat powiązań funkcji wykonawczych z wyszkoleniem bojowym żołnierzy jest bardzo uboga a w szczególności brak jest takich prac dotyczących grupy podchorążych. Pojedyncze badania dotyczą żołnierzy zawodowych (Hillman i wsp., 2000; Nibbeling i wsp., 2014); wskazano w nich na rolę koncentracji uwagi oraz skupienia dla osiągnięcia wysokich wyników w strzelaniu. Nie ulega wątpliwości, że problem badania funkcji wykonawczych wśród żołnierzy a w szczególności podchorążych kształconych na przyszłych dowódców powinien znajdować się nieprzerwanie w kręgu zainteresowań wojskowych naukowców. Przykładem może być kontrola hamowania (Schlaghecken i Eimer, 2006), której głównym zadaniem jest blokowanie zachowania i zatrzymywanie nieodpowiednich, automatycznych reakcji, zmieniając ostatecznie odpowiedź na lepszą, bardziej przemyślaną i dostosowaną do sytuacji (Palmwood i wsp., 2017). Poprawia ona zatem

efektywność wykonania zadania głównego i zwiększa prawdopodobieństwo sukcesu. Ponadto dowódcy wojskowi często wykonują pracę w warunkach wysokiego stresu, podejmując decyzje dotyczące życia lub śmierci swoich podwładnych, muszą zatem obierać odpowiednie strategie działania i regulować emocje.

Dodatkowo, przy obecnym stanie wiedzy, oczywistym są powiązania procesów związanych z uwagą, koncentracją oraz innymi funkcjami wykonawczymi ze sprawnością uczenia się przekładającą się na osiągnięcia akademickie. Dowiedziono, że zarówno uwaga, jak i kontrola impulsów znacząco wpływa i przewiduje osiągnięcia w nauce wśród młodzieży (Alavi i wsp., 2019). Wykazano, że problemy z uwagą w dzieciństwie konsekwentnie powodują gorsze wyniki w nauce w okresie dorastania (Fergusson i wsp., 1997), powodując nawet brak promocji do kolejnych klas czy nawet porzucanie nauki (Galéra i wsp., 2009). Większość badań prowadzonych była jednak w ośrodkach klinicznych, głównie wśród dzieci z diagnozowanymi lub wstępnymi objawami ADHD (Langberg i wsp., 2011; Pingault i wsp., 2011; Sayal i wsp., 2015). Jednakże tylko nieliczne publikacje poruszają problematykę uwagi i funkcji wykonawczych wśród młodzieży akademickiej niemającej problemów rozwojowych.

Warto również zaznaczyć, że badacze stosują różne miary osiągnięć akademickich. W literaturze określa się je m.in. na podstawie wyników w standaryzowanych testach, takich jak na przykład egzaminy na zakończenie etapów kształcenia czy egzaminy wstępne na studia. Jak się jednak okazuje, wyniki w takich testach stanowią ograniczoną definicję osiągnięć w nauce, które mogą, ale nie muszą ich odzwierciedlać (Loe i Feldman, 2007). Psychologia edukacji podkreśla natomiast, że to oceny z poszczególnych przedmiotów są jednym z głównych wskaźnikiem ogólnych osiągnięć akademickich (Keith i Benson, 1992). Wreszcie inne czynniki takie jak motywacja studenta, są zdecydowanie silniej związane z ocenami niż z wynikami w testach standaryzowanych (Barrington i Hendricks, 1989).

4.4. Wyszkolenie bojowe

Jednym z głównych elementów oceny sprawności i gotowości żołnierza do walki jest jego wyszkolenie bojowe. Na wyszkolenie bojowe składają się przede wszystkim elementy wyszkolenia strzeleckiego, taktycznego, medycznego, topograficznego oraz poziomu sprawności fizycznej.

Wyszkolenie strzeleckie sprowadza się głównie do umiejętności celnego i skutecznego prowadzenie ognia z broni indywidualnej i zespołowej. Strzelanie przy tym jest złożoną czynnością psychomotoryczną. Główne czynności jakie wykonuje żołnierz podczas strzelania to: przyjęcie postawy strzeleckiej (leżąc, stojąc, klęcząc itp.), zgrywanie przyrządów celowniczych (muszki i szczerbinka), celowanie (zgrane przyrządy celownicze ustawia się na celu w odpowiednim miejscu w zależności od warunków strzelania), odpowiednie oddychanie, ściąganie języka spustowego. Predykatorami wysokich wyników strzeleckich są zarówno czynniki fizjologiczne jak i psychologiczne (Lakie, 2010; McDermott i wsp., 2001). Wyniki badań Tremayne and Barry (2001) potwierdziły, że zarówno wybrane funkcje poznawcze, jak i sprawność motoryczna są istotne dla celnego i skutecznego strzelania (Tremayne i Barry, 2001). Biorąc pod uwagę powyższe, nie należy pominąć, że efektem metodycznego i optymalnego szkolenia strzeleckiego jest opanowanie umiejętności strzeleckiej. Warto też prowadzić badania dotyczące sprawności strzeleckiej żołnierzy, poszukując różnych zmiennych, które mogą pomóc w ulepszaniu programów kształcenia i szkolenia przyszłych oficerów Wojska Polskiego.

Wyszkolenie taktyczne to głównie umiejętność indywidualnego oraz zespołowego działania na polu walki, znajomość procedur oraz zdolność do wykonywania norm taktycznych (transport amunicji, pokonywanie terenu różnymi sposobami itp.). Medycyna bojowa sprowadza się do umiejętności indywidualnego opatrywania ran oraz taktyczno-bojowej opieki nad innym poszkodowanym. Topografia wojskowa to terenoznawstwo, umiejętność posługiwania się mapą wojskową, busolą jak również zdolność do wykonywania marszów na azymut w terenie oraz nawigacji w dzień i w nocy.

Wreszcie u podstaw oceny gotowości bojowej żołnierza nieprzerwanie leży jego sprawność fizyczna, która od zawsze była nieodzownym atrybutem służby wojskowej. Najważniejszym jednak celem sprawności fizycznej zgodnie z koncepcją H-RF jest pozytywne zdrowie fizyczne, które jest warunkiem braku problemów zdrowotnych a także pomaga angażować się w codzienne zadania z odpowiednią energią (Howley i Franks, 1992). Powiązanie sprawności fizycznej ze zdrowiem oraz badania nad innymi czynnikami z nią potencjalnie powiązanymi, takimi jak osiągnięcia akademickie, funkcje wykonawcze, sprawność strzelecka oraz wyszkolenie bojowe, nabierają szczególnego znaczenia w kształtowaniu

odpowiednich postaw oraz prozdrowotnych zachowań wśród przyszłych dowódców, szczególnie na etapie kształcenia w akademiach wojskowych (Oja i Tuxworth, 1995).

Literatura podejmująca badania nad sprawnością fizyczną jest niezwykle bogata. Stanowi ona przedmiot zainteresowań nie tylko wśród specjalistów zajmujących się motorycznością człowieka, ale również pośród antropologów, pedagogów, psychologów. W obszarze problematyki podejmowanej w niniejszej pracy doktorskiej badania dostępne w literaturze potwierdziły pozytywny wpływ sprawności fizycznej na osiągnięcia akademickie oraz na niektóre funkcje wykonawcze (Trudeau i Shephard, 2008). Dowiedziono, że oceny w trakcie nauki pozytywnie skorelowane są z poziomem sprawności fizycznej (Etnier i wsp., 1997; Hillman i wsp., 2005; Santana i wsp., 2017), spośród komponentów motorycznych największy wpływ na sprawność uczenia się wykazują zdolności wytrzymałościowe badanych (Castelli i wsp., 2007). W powyższych badaniach zależności te dotyczyły głownie przedmiotów o charakterze teoretycznym, podczas gdy w badaniach własnych analizowano również zależności z przedmiotami z modułu praktycznego, które bezpośrednio reprezentują poziom wyszkolenia bojowego podchorążych. Ponadto w życiu wojskowym, dla żołnierzy szczególne znaczenie ma poziom ich wytrzymałości oraz siły, zapewniający bezpieczne i efektywne wykonywanie fizycznej pracy wojskowej w warunkach garnizonowych oraz poligonowych (Aandstad, 2020).

W świetle rosnącego zainteresowania kobiet służbą wojskową kontynuuje się badania dotyczące różnic międzypłciowych żołnierzy w poziomie sprawności fizycznej. Badacze sugerują m.in., że zasadnym jest wprowadzenie ukierunkowanego programu treningowego dla żołnierzy kobiet, celem zmniejszenia fizjologicznych różnic międzypłciowych. Główne różnice obserwuje się w wydolności sercowo--oddechowej oraz sile mięśniowej. Ponadto kobiety poddawane są stosunkowo większemu stresowi fizjologicznego w porównaniu do mężczyzn podczas zintegrowanych ćwiczeń wojskowych, czego głównym powodem jest ich niższa sprawność aerobowa i mniejsza maksymalna siła mięśniowa (Vikmoen i wsp., 2020).

Podsumowując, opisane powyżej elementy bezpośrednio świadczą o gotowości żołnierza do prowadzenia walki na wypadek konfliktu zbrojnego jak również w czasie pokoju na wypadek kryzysu, podczas którego niezbędne będzie użycie wojska. Kryteria oceny wyszkolenia bojowego różnić się mogą w zależności od rodzaju wojsk czy zajmowanych stanowisk służbowych. Armie różnych państw stosować mogą

odmienne kryteria oceny wyszkolenia bojowego, ze względu na różne koncepcje organizacyjne sił zbrojnych, czy na przykład poziom zaawansowania technologicznego (Perić i wsp., 2013). Wiodącym modułem szkolenia w trakcie jednolitych studiów magisterskich na kierunku Dowodzenie w AWL jest moduł praktycznych przedmiotów wojskowych. W pierwszych etapach szkolenia, przedmiotami reprezentującymi wyszkolenie bojowe podchorążego są wychowanie fizyczne, szkolenie strzeleckie, topografia wojskowa oraz podstawy taktyki. Dlatego też w niniejszej pracy pod uwagę wzięto czynniki decydujące o poziomie osiągnięć akademickich z powyższych przedmiotów oraz poziomie opanowania umiejętności strzeleckich.

5. Cel badań

Celem badań było poszukiwanie związków pomiędzy poziomem sprawności fizycznej, funkcjami wykonawczymi, osiągnięciami akademickimi oraz poziomem wyszkolenia bojowego podchorążych a także zbadanie różnic międzypłciowych w poziomie tych cech wśród podchorążych Akademii Wojsk Lądowych we Wrocławiu.

Dla uszczegółowienia celu badań, postawione zostały następującej pytania badawcze:

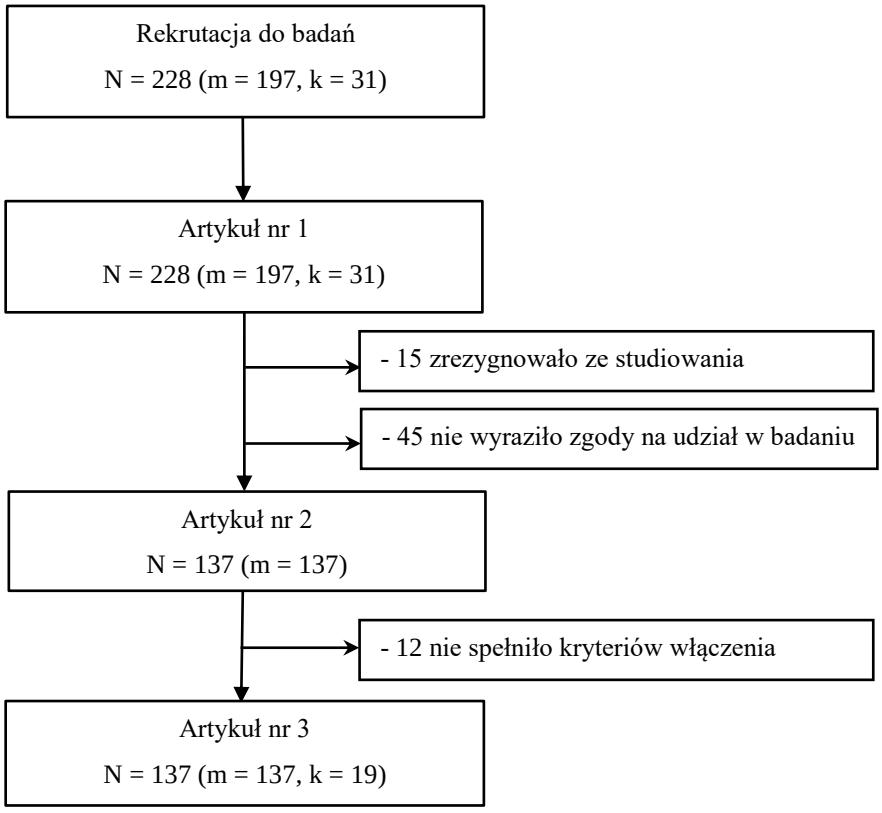
1. Czy obserwuje się różnice (jeśli tak, to jakie) między kobietami i mężczyznami w poziomie osiągnięć akademickich, funkcji wykonawczych i wyszkoleniu bojowym?
2. Czy występują zależności (jeśli tak, to jakie) między komponentami morfologicznymi i motorycznymi a osiągnięciami akademickimi w grupach kobiet i mężczyzn?
3. Czy wstępują zależności (jeśli tak, to jakie) między komponentami motorycznymi a poziomem wyszkolenia bojowego w grupie mężczyzn?
4. Czy występują zależności (jeśli tak, to jakie) między komponentami morfologicznymi i motorycznymi a poziomem funkcji wykonawczych w grupach kobiet i mężczyzn?
5. Czy wstępują zależności (jeśli tak, to jakie) między poziomem funkcji wykonawczych a poziomem wyszkolenia bojowego w grupie mężczyzn?
6. Czy występują zależności (jeśli tak, to jakie) między poziomem funkcji wykonawczych a osiągnięciami akademickimi w grupach kobiet i mężczyzn?

6. Grupa badawcza i metody badawcze

6.1. Charakterystyka grupy badanej

Badaniami objęto podchorążych AWL, którzy rozpoczęli jednolite studia magisterskie na kierunku Dowodzenie. Podchorążowie pełnili czynną służbę wojskową o charakterze kandydata na żołnierza zawodowego. Grupa badana liczyła 228 żołnierzy, w tym 31 kobiet i 197 mężczyzn w przedziale wiekowym 19–25 lat. Podchorążowie w efekcie 5 letniego szkolenia i kształcenia w AWL, promowani są na stopień podporucznika Wojska Polskiego i zajmują swoje pierwsze stanowiska służbowe w jednostkach wojskowych w roli dowódcy plutonu.

Kryterium włączenia do badań było wyrażenie świadomej zgody uczestnika na udział w badaniu oraz uzyskanie pełnej, bezwarunkowej promocji na kolejny semestr nauk. Podstawą prawną przeprowadzenia badań była zgoda Rektora – Komendanta AWL (nr 271 z dnia 18.01.2021 r.) oraz zgoda Komisji ds. Etyki Badań Naukowych Akademii Wychowania Fizycznego we Wrocławiu (nr 2/2021 z dnia 12.02.2021 r.). Wszystkie procedury wykonywane w tym badaniu z udziałem ludzi były zgodne z Deklaracją Helsińską.



Legenda: N – wielkość próby, m – mężczyźni, k – kobiety.

Rycina 1. Schemat sekwencji działań w przeprowadzonych badaniach

6.2. Zastosowane metody badawcze

6.2.1. Poziom rozwoju morfofunkcjonalnego

a) Komponenty morfologiczne:

Za pomocą wagi kolumnowej z zintegrowanym wzrostomierzem SECA 704S zmierzono:

- Wysokość ciała [mm] – zastosowano technikę Martina.
- Masę ciała z dokładnością pomiaru do 0,1 kg.

Pomiar wysokości i masy ciała każdorazowo został przeprowadzony w hali gimnastycznej w stroju sportowym (spodenki + koszulka z krótkim rękawem). Na podstawie zmierzonych parametrów somatycznych wyliczono wskaźnik masy ciała BMI (body mass index) wg. wzoru:

$$BMI = \frac{\text{Masa ciała [kg]}}{\text{Wysokość ciała}^2\ [\text{m}^2]}$$

b) Komponenty motoryczne zostały ocenione na podstawie pomiaru:

- Siły statycznej – pomiar za pomocą próby ścisku dynamometru dłoniowego.
- Szybkości – określana za pomocą biegu wahadłowego 10×5 m.
- Wytrzymałości – określana za pomocą biegu na dystansie 1000 m.

Pomiary poziomu rozwoju motorycznego przeprowadzone każdorazowo w stroju sportowym w hali gimnastycznej (spodenki + krótka koszulka). Badanie poprzedzone zostało kilkuminutową rozgrzewką, słownym komentarzem oraz pokazem. Kolejność testów zawsze była taka sama.

6.2.2. Ocena funkcji wykonawczych

Dla oceny procesów związanych z niektórymi funkcjami wykonawczymi (celowe przeszukiwania materiału, utrzymania i przerzutności uwagi, sekwencyjne przetwarzanie informacji oraz monitorowanie własnego zachowania) wśród grupy badawczej przeprowadzony został Kolorowy Test Połączeń (CTT) w wersji dla dorosłych.

6.2.3. Ocena osiągnięć akademickich

Sprawność uczenia się określona została na podstawie semestralnych wyników akademickich (ocen) z przedmiotów:

- cywilnych: humanistycznych i społecznych oraz ścisłych i przyrodniczych,
- wojskowych: teoretycznych i praktycznych.

Uwzględniona w analizie ocena z danej grupy przedmiotów stanowiła średnią arytmetyczną ocen studenta wchodzących w skład danej grupy osiągnięć akademickich. Grupę przedmiotów cywilnych humanistycznych i społecznych stanowiły: historia polski, język angielski, podstawy zarządzania, cywilnych ścisłych i przyrodniczych: informatyka w dowodzeniu, matematyka, natomiast do grupy przedmiotów wojskowych teoretycznych zaliczono: kształtowanie postaw patriotycznych, teoria bezpieczeństwa i klasyfikacja zagrożeń oraz do przedmiotów wojskowych praktycznych: wychowanie fizyczne, szkolenie strzeleckie, topografia wojskowa.

6.2.4. Ocena wyszkolenia bojowego

Celem określenia poziomu wyszkolenia bojowego podchorążych analizie poddano ich wyniki pozyskane ze szkolenia strzeleckiego oraz osiągnięcia akademickie z praktycznych przedmiotów wojskowych (wychowanie fizyczne, taktyka, topografia). Strzelania określiły umiejętność prowadzenia ognia do celów stałych oraz ruchomych z różnych postaw strzeleckich i zostały przeprowadzone podczas zajęć programowych z przedmiotu szkolenie strzeleckie.

6.3. Analizy statystyczne

Zgromadzone wyniki zostały poddane szczegółowej analizie statystycznej, stosując w zależności od potrzeb następujące metody statystyczne:

- normalność rozkładu poszczególny zmiennych oceniono na podstawie testu Shapiro-Wilka oraz testu Kołmogorowa-Smirnowa w zależności od liczebności grup i podgrup badanych;
- obliczono wartości średnie, odchylenia standardowe (SD), współczynniki zmienności (v) oraz poziomy ufności;
- w celu określenia istotności statystycznej różnic pomiędzy badanymi zmiennymi wyodrębnionych grup podchorążych ze względu na płeć przeprowadzona została analiza wariancji dla klasyfikacji jednoczynnikowej ANOVA;

- istotność różnic między dwoma średnimi obliczono testem t-Studenta dla prób niezależnych oraz za pomocą testu U Manna-Withneya dla prób niezależnych;
- aby określić które ze średnich różnią się między sobą w pracy wykorzystano standardową procedurę wielokrotnych porównać post-hoc w postaci testu NIR (najmniejszych istotnych różnic);
- związki między zmiennymi wyjaśnianymi a wyjaśniającymi oceniono za pomocą korelacji Spearmana oraz Pearsona, posługując się następującą interpretacją:
  - korelacja niska $0,0 < r \leq 0,4$,
  - korelacja umiarkowana $0,4 < r \leq 0,7$,
  - korelacja wysoka $0,7 < r \leq 0,9$,
  - korelacja bardzo wysoka $0,9 < r \leq 1,0$.
- zależności pomiędzy badanymi zmiennymi wyjaśnianymi a wyjaśniającymi przeanalizowano za pomocą regresji optymalnej, metodą najlepszego podzbioru oraz za pomocą regresji krokowej postępującej. Pozwoliło to wyznaczyć optymalny zbiór zmiennych wyjaśniających.

Równanie regresji wyznaczone w wynik obliczeń miało postać:

$$\text{Zmienna wynikowa} = \beta_0 + \beta_1 x_1 + ... + \beta_p x_p + e,$$

gdzie: β_0 – wyraz wolny równania regresji,

$\beta_1,...,\beta_p$ – współczynnik równania regresji,

$x_1,..., x_p$ – zmienne niezależne,

e – niezależne błędy losowe.

Celem określenia, w ilu procentach zmienne niezależne wyjaśniają zmienność wyników zmiennej zależnej, wartość współczynnika determinacji wielorakiej R^2 pomnożona została przez 100%.

Dodatkowo w analizie uwzględniony został standaryzowany współczynnik regresji częściowej beta (β). Informuje on o tym, na ile zmieni się zmienna zależna wskutek standaryzowanej zmiany zmiennej niezależnej.

Istotność statystyczna w pracy, w przypadku wszystkich zastosowanych testów przyjęta została na poziomie $p < 0,05$. Obliczenia wykonano w programie Statistica v. 13 firmy StatSoft w Pracowni Badań Biostruktury Akademii Wychowania Fizycznego we Wrocławiu, posiadającej certyfikat ISO 9001.

7. Podsumowanie

Artykuł nr 1 pt**. „Influence of Physical Fitness and Attention Level on Academic Achievements of Female and Male Military Academy Cadets in Poland”** przedstawia analizę związków pomiędzy poziomem sprawności fizycznej i wybranymi funkcjami wykonawczymi a osiągnięciami akademickimi podchorążych w AWL.

Współczesna służba wojskowa na stanowiskach dowódczych stawia niezmienne wysokie wymagania w obszarze sprawności fizycznej. Jednakże rosnącą wartością staje się również ponadprzeciętna sprawności w zakresie intelektu i funkcjonowania poznawczego. Objawia się ona m.in. w umiejętności dostosowania się do zmieniających się warunków, kreatywności czy „stabilności poznawczej” rozumianej jako odporności na stres czy zdolności do samoregulacji. Ponadto, osiągnięcie zamierzonych efektów kształcenia podchorążych jest wyrażone przez ich osiągnięcia akademickie, które z kolei powiązane są z poziomem funkcji wykonawczych. Co więcej, w ostatnich latach obserwuje się znaczny wzrost zainteresowania służbą wojskową wśród kobiet, dlatego też badania nad powiązaniami sfery poznawczej z fizyczną są ważne pod kątem różnic międzypłciowych.

Wyniki badań wykazały istotną różnicę pomiędzy kobietami i mężczyznami w zakresie poziomu osiągnięć akademickich. Mężczyźni osiągali istotnie wyższe oceny z praktycznych przedmiotów wojskowych. W grupie kobiet siła ręki dominującej okazała się być istotną determinantą wyników w nauce wyjaśniając wspólnie z testem uwagi CTT-1 39,9% zmienności wyników przedmiotów cywilnych (humanistycznych i społecznych), wspólnie z masą ciała oraz wysokością 50,8% zmienności wyników przedmiotów cywilnych (ścisłych i przyrodniczych) oraz wspólnie z wskaźnikiem masy ciała BMI, masą ciała oraz wysokością 44,1% zmienności wyników przedmiotów wojskowych (teoretycznych).

Na podstawie powyższych badań, można stwierdzić, że główny nacisk w szkoleniu wojskowych podchorążych, a w szczególności wśród kobiet zwrócony powinien być na rozwój i utrzymanie wysokiego poziomu siły. Przykładem ukierunkowanych zajęć mogą być dodatkowe treningi obwodowe na siłowni, z własnym ciężarem ciała, marsze z ciężarami, pokonywanie torów przeszkód czy crossfit.

Artykuł nr 2 pt**. „Alternating Attention and Physical Fitness in Relation to the Level of Combat Training”** przedstawia analizę związków pomiędzy poziomem wybranych funkcji wykonawczych i sprawności fizycznej a poziomem wyszkolenia bojowego (sprawnością strzelecką oraz osiągnięciami akademickimi z praktycznych przedmiotów wojskowych).

Zdolność do obrony granic oraz potencjał operacyjny sił zbrojnych sprowadza się w dużej części do poziomu wyszkolenia bojowego pojedynczego żołnierza. Szczególnie ważne jest dla przyszłego dowódcy jako organizatora i realizatora szkolenia na poziomie plutonu, kompanii i kolejnych struktur wojskowych. Bezapelacyjnie to wysoka sprawność fizyczna i poznawcza każdego żołnierza warunkuje jego gotowość do prowadzenia działań wojennych i mobilizacyjnych. Poziom wyszkolenia bojowego można oceniać na podstawie różnych parametrów w zależności od etapu szkolenia oraz przeznaczenia i rodzaju sił zbrojnych. Wśród podchorążych za poziom wyszkolenia bojowego uznaje się poziom ich sprawności strzeleckiej i fizycznej oraz poziom wyszkolenia taktycznego i topograficznego. W literaturze przedmiotu wśród potencjalnych determinantów wyszkolenia bojowego pomijano jak dotąd sferę poznawczą, skupiając uwagę głównie na sprawności fizycznej. Dlatego w niniejszym artykule przeprowadzono analizę związków między poziomem funkcji wykonawczych a wyszkoleniem bojowym podchorążych.

Znacząco wyższe osiągnięcia akademickie z praktycznych przedmiotów wojskowych związane były z większym poziomem siły oraz lepszą wytrzymałością mężczyzn. Sprawność fizyczna badanych nie stanowiła istotnej zmiennej wpływającej znacząco na ich celność strzelecką. Głównym wynikiem pracy jest ujawnienie się poziomu funkcji wykonawczych jako silnego determinanta sprawności strzeleckiej podchorążych. Ostatecznie w modelu predykcji celności strzelania znalazła się tylko jedna zmienna istotnie statystyczna – wyniki Kolorowego Test Połączeń CTT-2 (β = -0,566). Poziom funkcji wykonawczych, badany powyższym testem, istotnie wyjaśnia 31,5% zmienności wyników strzeleckich podchorążych (skorygowane R^2 = 0,315).

Problem sprawności strzeleckiej i czynników na nią wpływających pozostaje jednak otwarty. Niemniej jednak, w przyszłości warto prowadzić kolejne badania po zastosowaniu ćwiczenia stymulacji poznawczej (np. *mindfulness-based attention training* (Nassif i wsp., 2021) czy *active-response-inhibition training* (Biggs i wsp., 2015)) w celu podniesienia poziomu sprawności strzeleckiej.

Artykuł nr 3 pt. **„Executive Function Level in Cadets' Shooting Performance"** przedstawia analizę powiązań funkcji wykonawczych ze sprawnością strzelecką oraz różnic międzypłciowych w poziomie tych cech wśród podchorążych AWL.

Funkcje wykonawcze pełnią kluczową rolę w zachowaniu się w niespodziewanych sytuacjach, w których to ich użycie warunkuje sukces w działaniu. Do takich sytuacji zaliczyć można zdarzenia i czynności niebezpieczne, trudne technicznie oraz wymagające korekty błędów (Diamond, 2013). Potencjalnie, poziom funkcji wykonawczych jest również ważny w służbie wojskowej a w szczególności ich poziom powiązany może być z sprawnością strzelecką. Czynności strzelca podczas strzelania w swej strukturze technicznej wymagają od niego m.in. skupienia uwagi na celu, przerzutności uwagi oraz monitorowania własnego zachowania. W artykule podjęto próbę odpowiedzi na pytanie czy sprawność strzelecka podchorążych powiązana będzie z ich poziomem funkcji wykonawczych. Dodatkowo analizie poddano potencjalne różnice międzypłciowe w poziomie sprawności strzeleckiej oraz funkcji wykonawczych.

Wyniki badań nie ujawniły istotnych różnic pomiędzy kobietami oraz mężczyznami w poziomie funkcji wykonawczych oraz w sprawności strzeleckiej. Natomiast okazało się, że wyższe wyniki strzeleckie osiągane przez mężczyzn we wszystkich strzelaniach z badania tj. w strzelaniu z karabinka, z pistoletu wojskowego, z pistoletu maszynowego jak również w strzelaniu z karabinka w masce przeciwgazowej, oraz przez kobiety w strzelaniu z pistoletu były silnie istotnie powiązane z wyższymi funkcjami wykonawczymi.

Dokładniejsza analiza specyficznych funkcji poznawczych ważnych z punktu widzenia sprawności strzeleckiej, może pomóc w opracowaniu i wdrożeniu ukierunkowanych interwencji doskonalących programy szkolenia strzeleckiego, nie tylko w służbie wojskowej, ale także w innych służbach w których broń jest podstawowym narzędziem pracy.

8. Wnioski

1. Badanie funkcji poznawczych, osiągnięć akademickich oraz wyszkolenia bojowego pozwoliło lepiej zrozumieć funkcjonowanie w obszarze tych zmiennych oraz wzajemne ich zależności w grupie podchorążych.
2. Szkolenie w jednostkach wojskowych przeprowadza się zwykle w mieszanych płciowo plutonach. Mając świadomość idących za tym wyzwań organizacyjnych, pod rozwagę należałoby wziąć wprowadzenie fizycznego treningu uzupełniającego dla kobiet. Celem dodatkowego programu szkolenia powinna być głównie poprawa w zakresie siły mięśniowej, jako jednego z głównych czynników ważnych w służbie wojskowej, tym bardziej, że siła okazała się być ważną zmienną dla osiągnięć akademickich podchorążych kobiet.
3. Dokładniejsza analiza roli innych funkcji wykonawczych wśród podchorążych może pomóc w zrozumieniu zależności między funkcjami wykonawczymi a innymi zmiennymi kluczowymi dla wyszkolenia bojowego żołnierzy. Przykładem może być wyszkolenie strzeleckie, dla którego funkcje wykonawcze okazały się być istotnym determinantem.
4. Podchorążowie zarówno kobiety jak i mężczyźni reprezentują podobny poziom funkcji wykonawczych jak i sprawności strzeleckiej, dlatego też nie powinno się różnicować obciążenia oraz sposobów oceny w szkoleniu ze względu na płeć.
5. Prowadzenie w przyszłości podobnych badań wśród podchorążych może przełożyć się na optymalizację procesu szkolenia w akademiach wojskowych, które odgrywają ważną rolę w systemie obronnym państwa.

9. Opublikowane prace

9.1. Influence of Physical Fitness and Attention Level on Academic Achievements of Female and Male Military Academy Cadets in Poland

healthcare

MDPI

Article

Influence of Physical Fitness and Attention Level on Academic Achievements of Female and Male Military Academy Cadets in Poland

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Abstract: A professional soldier should be characterized not only by high physical fitness but also by high intellectual and cognitive skills. Therefore, it is important to focus on the future commanding cadre-cadets that are educated in military academies. The aim of the study was to look for correlations between the level of physical fitness and attention and academic achievements (AA) in different subjects among cadets studying at military academies. The research group consisted of students of a military academy in Poland, i.e., 228 cadets, including 31 women and 197 men. Correlations between explained and explanatory variables were assessed using Pearson's correlation. Correlations between AA and somatic parameters and motor components were analysed using optimal regression, using the best subset method. A statistical difference was found between men and women in terms of the level of somatic and motor development; men also performed significantly better in practical military subjects. In the female group, dominant hand strength is a significant determinant of AA in civilian and theoretical military subjects. The findings suggest the need for specialized training aimed at bridging the major differences in physical fitness between men and women by placing greater emphasis on muscle strength development.

Keywords: physical fitness; academic achievements; attention; army cadets; women

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1. Introduction

High physical fitness has always been perceived as an indispensable attribute of a soldier. It is still the basis for assessing the combat value of the modern army. Despite the progressive civilizational development, digitalization and robotization, military service will always be associated with high physical fitness.

The most important goal of physical fitness is positive physical health, which determines the low risk of health problems and also the development of the ability to engage in daily tasks with adequate energy [1].

With the current knowledge, there is no doubt that physical activity has many health benefits. It is an important protective factor against many health disorders and chronic non-infectious diseases such as obesity, type 2 diabetes, cardiovascular diseases (hypertension, cardiac arrest) and age-related diseases such as dementia and Alzheimer's disease [2]. The risk of diseases such as osteoporosis and ischemic heart disease in adulthood can be reduced by regular physical activity from an early age [3–5].

In addition, researchers have confirmed the positive effects of exercise on cognitive function due to increased blood flow to the brain; more neurotransmitters; improved plasticity, focus and attention; and more efficient information processing [6–9]. More frequent physical activity is associated with higher levels of cognitive processing by increasing control over these processes [10], and early intervention to support the uptake of physical

activity may be important for maintaining cognitive health, particularly in adulthood and old age [7].

The literature on the links between physical fitness and learning performance is quite extensive. Studies support a positive correlation between physical fitness and academic achievement and its impact on some cognitive functions [11–15]. Examination scores and grades during learning, directly representing the level of cognitive functions, significantly correlate with physical fitness [16–18]. Physical fitness is positively correlated with academic achievement and also negatively correlated with BMI [19]. Physical activity is positively related with cognitive function [20–23].

In a study by Bezold et al. [24], an increase in physical fitness level over the course of a year of schooling led to higher academic achievement achieved by students compared to other subjects whose fitness level did not change. At the same time, a decrease in physical fitness level was associated with lower academic performance.

Implementing an adequate amount of physical exercise during childhood may ensure better cognitive fitness that translates into, among other things, better academic performance, especially in a risk group such as those who are prematurely born [25].

A low level of cardiorespiratory fitness combined with low cognitive fitness in early adulthood results in a higher risk of dementia and mild cognitive impairment in later life [26]. Attention to cardiorespiratory fitness may help to reduce the deleterious effects of aging on brain structures [27].

Physical exercise can be an important instrument in public health efforts, as well as in projects that optimize educational achievement, cognitive abilities, and prevention efforts against civilization diseases at the community level [28].

With the current state of knowledge, it is obvious that processes related to attention, concentration and other executive functions are linked to learning performance reflected in academic performance. Recent studies support these correlations [29–32]. Most studies have been conducted in clinical settings. However, only a few publications have addressed attention and executive functions among academic adolescents without developmental problems. There is also a lack of such studies among cadets. Therefore, our own research was enriched by conducting the adult version of the Color Trail Test (CTT).

The CTT is a cross-cultural version of the neuropsychological Trail Making Test (TMT) that minimizes the impact of language differences. It examines the efficiency of processes related to attention and executive functions (sequencing, mental flexibility, visual search as well as motor skills). For our study, we used the first and second part of the Color Trail Test, which are equivalents of the TMT Part A and Part B [33].

The dynamics of changing conditions on the battlefield, the constant flow of information and the need to make the right decision, often under a time regime, require from a soldier (and especially from a commander-leader) extremely highly developed cognitive functions. The specific nature of military service places before soldiers the expectations of rapid learning, efficient assimilation of specialized knowledge and also operating in practice of specific psychomotor skills.

The research also focused on the military service of women. Relatively recently, they have been permitted to study in military academies. There are currently 917 women studying in Poland. Normative documents give female and male soldiers the same rights and impose the same obligations [34].

Researchers addressing the issue of women's physical fitness in the military have demonstrated, among other things, that female soldiers experience a greater physiological load when performing the same operational (physical) tasks as men. During military exercises, women are at greater risk for musculoskeletal injuries. This may be due to the need to exert relatively more effort to perform psychomotor tasks at a similar level as men [35,36].

There is a lack of research in the military academies addressing the links between physical fitness and attention with intellectual fitness as manifested in academic achieve-

ment, among other things. This problem seems to be particularly relevant at the stage of training future commanders.

The aim of this study is to search for the correlation between the level of physical fitness and attention and learning performance in various subjects of female and male cadets studying at the military academy.

2. Materials & Methods

In order to find relationships between physical fitness and attention levels and AA in different subjects among female and male cadet groups, we designed a cross-sectional study. This allowed us to examine the hypothesized relationships between the study variables after the first semester of studies.

The study was based on the consent of the Rector-Commandant of the Military University of Land Forces (no. 271 dated 18 January 2021) and the approval of the Research Ethics Committee of the Wroclaw University of Health and Sport Sciences (no. 2/2021 dated 12 February 2021). Recruitment for the study took place on 22 February 2021, which included an organizational meeting, presentation of the study design and submission of conscious consent to participate in the study. All data were collected in February 2021 at the Military University of Land Forces in Wroclaw.

The study group consisted of students from the Military University of Land Forces in Wroclaw who were admitted to the first year of studies in the field of Commanding in the academic year 2020/2021—that is, 228 cadets, including 31 women (age = 20.91, SD = 1.19) and 197 men (age = 20.66, SD = 1.30).

To determine the level of physical fitness, measurements and tests of individual fitness components were conducted according to the concept of health-related fitness (H-RF):

1. Anthropometric measurements

Anthropometric measurements (body height and mass) were performed in sportswear in the sports hall. Height (accuracy of measurement 1 mm) and body mass (accuracy of measurement 0.1 kg) were measured using the Martin technique with a medical anthropometer SECA. Based on the measured somatic parameters, body mass index (BMI) was calculated. Basic data on age and sex of the subjects were obtained from a questionnaire.

2. Motor components

Motor components were assessed by measuring static hand strength and speed (10 × 5 m shuttle run). The examination was preceded by a warm-up, demonstration and verbal commentary, according to the guidelines of "Eurofit for adults" [37].

a. Dominant hand strength

Hand strength was measured using a Stanley hydraulic hand dynamometer with a measurement accuracy of 1 kg. The subject, holding the dynamometer in the fitter hand away from the torso, clenched the hand as hard as they could. The pointer on the dynamometer stops at the highest reading until it is zeroed. The test was performed twice, with the better result used for analysis.

b. Running speed

The subject stood in a starting position with both of their feet in front of the line. After the command "START", they ran as fast as they could to the second line 5 m away, crossed it with both feet, and came back. During the run, and especially during the turns, the subjects were not allowed to support themselves with hands on the floor. The test was performed once.

3. Attention

Processes related to attention and some executive functions were examined using the Color Trails Test (CTT) in CTT-1 and CTT-2 versions.

The test is performed on an A4 sheet on which there are pink and yellow numbered circles. For CTT-1, the respondent uses a pencil to connect consecutively numbered circles from 1 to 25 as quickly as possible, while for the second part (CTT-2), the respondent connects consecutively numbered circles alternating between pink and yellow as quickly as

possible. The time of completion of each trial and qualitative performance characteristics are recorded.

The tests were conducted and checked by Dariusz Jamro, M.Sc., an academic lecturer at the Military University of Land Forces who has the necessary skills in the research tool used. Measurements were made in accordance with all the requirements [33]. Measurement errors may have occurred during the validation of the test. No errors are noted in the application of the tool itself in a population without cognitive health problems.

4. Academic Achievements

AAs were determined by the arithmetic mean of grades in the subjects:

c. Civil subjects: humanities and social subjects (Polish history, English language, basics of management) and science and natural sciences (computer science in command, mathematics);
d. Theoretical military subjects (shaping patriotic attitudes, security theory and classification of threats);
e. Practical military subjects (physical education, shooting training, military topography).

Physical fitness tests and anthropometric measurements were always performed at the same time of day and in the same place. The warm-up always had the same form. The CTT tests were performed on a single day in a lecture hall with a thorough explanation of how to perform the test. The correctness and evaluation of CTT performance was checked twice. Data were collected by the physical education staff of the Department of Physical Education and Sports at the Military University of Land Forces specialized in scientific research.

Quantitative variables in the form of physical fitness components (age, weight, height, BMI, handgrip strength, running speed and agility) and attention-related variables (CTT-1 and CTT-2) were treated as explanatory variables in this study. Quantitative variables in the form of academic achievement (mean grades in each group of subjects) were the explained variables.

3. Statistical Analysis

The collected results were subjected to detailed statistical analysis by calculating for all variables: normality of the distribution of individual variables was assessed using the Shapiro–Wilk test (for the group of women, N = 31) and the Kolmogorov–Smirnov test (for the group of men, N = 196), relationships between explained and explanatory variables were assessed using Pearson's correlation and relationships between AA and somatic parameters and motor components were analysed using optimal regression, using the best subset method. The condition of normal distribution was met in order to apply the method of optimal regression. This made it possible to determine the optimal set of explanatory variables (taking into account the interdependencies between them) that could best predict the performance of the explained variable. We decided to include four variables in each model because of the different types of variables analysed in the article—(1) anthropometric variables: age, body height, body mass; (2) strength as a component highly desirable for military service; (3) speed as a component related to cognitive speed; and (4) variables related to attention level: CTT-1 and CTT-2. The authors subjectively expected that each type of variable could enter the model. Statistical significance in the study, for all tests used, was taken at $p < 0.05$.

All calculations were performed in a professional program Statistica v. 13 from StatSoft Poland in the Department of Biostructure of the Wroclaw University of Health and Sport Sciences, certified by ISO 9001.

4. Results

Among the somatic traits and motor components, significantly higher scores were registered in males (Table 1). In contrast, females obtained higher results in a test checking the level of attention and some executive functions, with statistically significantly better results in CTT-2 (61.97 ± 11.94, $p = 0.0230$). Differences in CTT-1, although noticeable, also

turned out not to be statistically significant in favour of females (30.87 ± 9.44, $p = 0.0748$) (Table 1).

Table 1. Variation in mean values of morphological and motor characteristics as well as AA and attention level by Student's *t*-test for independent samples between men and women.

Variable	Men (N = 197)			Women (N = 31)			*T*-test		g
	$\bar{x}$	sd	v	$\bar{x}$	sd	v	*t*	*p*	
Age [years]	20.66	1.30	6.27	20.91	1.19	5.70	−1.02	0.3076	0.19
Body height [cm]	179.38	5.66	3.15	167.67	4.04	2.41	11.07	**0.0000**	2.14
Body mass [kg]	77.69	7.86	10.12	63.37	4.49	7.09	9.88	**0.0000**	1.90
BMI [kg/m^2]	24.13	2.06	8.54	22.50	1.39	6.19	4.23	**0.0000**	0.82
Strength of the dominant hand [kg]	124.62	18.73	15.03	88.87	13.77	15.49	10.20	**0.0000**	1.97
Shuttle run 10 × 5 m [s]	18.45	1.02	5.53	19.63	0.83	4.22	−6.12	**0.0000**	1.18
CTT-1 [s]	33.96	8.87	26.11	30.87	9.44	30.58	1.79	0.0748	0.34
CTT-2 [s]	68.42	14.96	21.86	61.97	11.94	19.27	2.29	**0.0230**	0.31
Civil subjects (humanities and social sciences) [grade]	4.40	0.29	6.63	4.46	0.33	7.35	−0.93	0.3529	0.20
Civil subjects (science and natural sciences) [grade]	3.90	0.27	6.96	4.02	0.21	5.16	−2.44	**0.0155**	0.46
Military subjects (theoretical) [grade]	4.70	0.26	5.61	4.73	0.25	5.35	−0.52	0.6005	0.12
Military subjects (practical) [grade]	4.20	0.30	7.13	3.98	0.36	9.06	3.65	**0.0003**	0.80

$\bar{x}$—mean, sd—standard deviation, v—coefficient of variation, g—Hedges' g effect size. Bold indicates $p < 0.05$.

Among the analysed groups of subjects, significant differences occurred in the results of civilian (science and natural sciences) and military (practical) subjects. Women performed better in civilian subjects (science and natural sciences) (4.02 ± 0.21, $p = 0.0155$), while men showed better results in military (practical) subjects (4.20 ± 0.30, $p = 0.0003$). The differences in AA in the other groups of subjects, i.e., civil subjects (humanities and social sciences) and military subjects (theoretical), were not statistically significant.

The analysis of simple correlations between the analysed somatic and motor variables, level of attention, and AA allow us to state that in the female group, the correlations are partially statistically significant (Table 2). Achievement in civil subjects (humanities and social sciences) and CTT-1 test scores appeared to be positively correlated with dominant hand strength.

The highest correlations were found in the results obtained in civil subjects (sciences and natural sciences). They correlated positively with body weight, body mass index BMI and right-hand grip strength.

In the analysis of the correlations between components of physical fitness, attention level and AA in the male group, there are essentially no correlations (Table 3). Dominant hand strength was positively associated with performance in civilian subjects (science and natural sciences). In contrast, higher scores in military (theoretical) subjects were favoured by lower hand strength. Men with greater body height achieved better results in military (practical) subjects; however, the strength of this correlation was very weak.

The results of the regression analysis show that the strength of the dominant hand turned out to have the greatest influence on AA in civilian and military (theoretical) subjects in the female group; these relationships were revealed in the analysis of simple correlations as well as in the regression analysis (Tables 2 and 4). In this case, it is a strong determinant of AA in civilian and military (theoretical) subjects, which can explain, together with the CTT-1 attention test, 30.7% of the variation in civilian (humanities and social sciences) results; together with body mass and height, 43.2% of the variation in civilian (science and natural sciences) results; and together with BMI, body mass and height, 35.5% of the variation in military (theoretical) results. The appearance of body mass in the regression models, on the other hand, seems simple to explain, as many studies show a relationship between static strength and body mass, which is, after all, the biological basis of this ability.

Table 2. Correlations between the studied characteristics in the female group. Bold, highlighted correlation coefficients are significant with $p < 0.05$.

Variable	95% CI	Age	Body Height	Body Mass	BMI	CTT-1	CTT-2	Hand Grip	Shuttle Run 10 × 5 m
Age	20.47–21.35	-	0.10	0.13	0.05	−0.08	0.03	0.21	−0.15
Body height	166.19–169.16	0.10	-	**0.57**	−0.25	−0.05	0.05	0.23	−0.05
Body mass	61.72–65.02	0.13	**0.57**	-	**0.64**	0.22	0.28	**0.52**	−0.19
BMI	21.99–23.01	0.05	−0.25	**0.64**	-	0.34	0.32	**0.38**	−0.20
CTT-1	27.41–34.33	−0.08	−0.05	0.22	0.34	-	**0.63**	−0.15	**0.41**
CTT-2	57.59–66.35	0.03	0.05	0.28	0.32	**0.63**	-	−0.26	0.26
Hand grip	83.82–93.92	0.21	0.23	**0.52**	**0.38**	−0.15	−0.26	-	−0.14
Shuttle run 10 × 5 m	19.33–19.93	−0.15	−0.05	−0.19	−0.20	**0.41**	0.26	−0.14	-
Civil subjects (humanities and social sciences)	4.34–4.58	0.01	0.20	0.31	0.19	0.11	−0.22	**0.52**	−0.11
Civil subjects (science and natural sciences)	3.95–4.10	0.29	−0.08	**0.43**	**0.57**	0.04	−0.02	**0.55**	−0.26
Military subjects (theoretical)	4.63–4.82	0.18	0.16	0.14	0.07	−0.30	−0.29	**0.53**	−0.21
Military subjects (practical)	3.85–4.12	−0.08	−0.05	−0.27	−0.25	−0.18	−0.27	0.02	−0.10

CI—confidence interval, bold indicates statistical significance ($p < 0.05$).

Table 3. Associations between the studied characteristics in the male group. Correlation coefficients highlighted in bold are significant with $p < 0.05$.

Variable	95% CI	Age	Body Height	Body Mass	BMI	CTT-1	CTT-2	Hand Grip	Shuttle Run 10 × 5 m
Age	20.48–20.84	-	0.02	0.10	0.08	−0.01	0.07	0.00	0.11
Body height	178.59–180.18	0.02	-	**0.54**	−0.12	0.07	−0.09	0.10	−0.01
Body mass	76.59–78.80	0.10	**0.54**	-	**0.76**	0.10	−0.07	0.13	0.03
BMI	23.84–24.41	0.08	−0.12	**0.76**	-	0.06	−0.03	0.08	0.05
CTT-1	32.72–35.21	−0.01	0.07	0.10	0.06	-	**0.42**	0.02	−0.01
CTT-2	66.32–70.52	0.07	−0.09	−0.07	−0.03	**0.42**	-	0.10	−0.01
Hand grip	121.99–127.26	0.00	0.10	0.13	0.08	0.02	0.10	-	**−0.19**
Shuttle run 10 × 5 m	18.31–18.59	0.11	−0.01	0.03	0.05	−0.01	−0.01	**−0.19**	-
Civil subjects (humanities and social sciences)	4.36–4.44	−0.13	0.10	0.06	0.00	−0.06	−0.05	−0.06	0.04
Civil subjects (science and natural sciences)	3.86–3.94	0.03	−0.07	−0.01	0.04	−0.05	0.06	0.12	−0.07
Military subjects (theoretical)	4.66–4.74	0.03	0.10	0.06	0.01	0.04	0.06	**−0.19**	0.04
Military subjects (practical)	4.16–4.24	0.06	**0.17**	0.14	0.04	0.03	−0.06	0.04	0.02

CI—confidence interval, bold indicates statistical significance ($p < 0.05$). AA in the respective subject groups shows a different correlation in tested variables in groups of men and women.

In the male group, the result of regression analysis showed only one statistically significant model. Academic achievement in military theoretical subjects was favored by lower hand grip strength, higher body mass index, lower body weight, and higher body height. In the model, these variables collectively explained 6.5% of the variability in performance in military theoretical subjects.

Table 4. Results of regression analysis (using the best in terms of adjusted R^2 4-element subset method) of AA of men and women as a function of their morpho-functional development and level of attention. Standardized Coefficients β highlighted in bold are significant with $p < 0.05$.

		Test for Full Model			Standardized Coefficients β for Selected Variables							
Variable	**Sex**	**F**	***p***	**Adjusted R^2**	**Age**	**Body Height**	**Body Mass**	**BMI**	**CTT-1**	**CTT-2**	**Hand Grip**	**Shuttle Run 10 × 5 m**
Civil subjects (humanities and social sciences)	w	**4.32**	**0.0082**	**0.307**		0.135			**0.425**	−0.379	**0.459**	
	m	1.90	0.1113	0.018	0.133	0.116			−0.072		−0.074	
Civil subjects (science and natural sciences)	w	**6.70**	**0.0008**	**0.432**	0.195	**−0.465**	**0.488**				**0.365**	
	m	1.33	0.2590	0.007		−0.068			−0.075	0.070	0.123	
Military subjects (theoretical)	w	**5.14**	**0.0035**	**0.355**		**2.181**	**−2.855**	**2.191**			**0.674**	
	m	**4.41**	**0.0020**	**0.065**		**1.280**	**−1.793**	**1.554**			**−0.198**	
Military subjects (practical)	w	1.28	0.3016	0.037		1.313	−1.794	1.309		−0.248		
	m	1.80	0.1306	0.016	0.059	0.128	0.060			−0.048		

Adjusted R^2—coefficient of determination, β significant at $p < 0.05$—marked in bold, w—women, m—men.

5. Discussion

A future professional soldier should be characterized not only by high physical fitness but also by high intellectual and cognitive skills. The aim of the training of cadets at the Military University of Land Forces is for graduates to have the ability to recognize, diagnose and solve problems while commanding a subunit, including leadership, education, training, methodology, managing human resources, effective communication, as well as negotiation and responsibility for commanding and training subordinates.

The main results of our study are the results of correlation and regression analysis in the female group, indicating that the level of physical fitness (mainly the strength component) but also partially the level of attention, body mass and BMI influenced the academic achievements of female cadets. Strength level significantly positively correlated with performance in three of the four subject groups analysed. Additionally, hand muscle strength entered three significant models with a high adjusted R^2 fit coefficient, explaining the variability in academic achievement. It should also be noted that in the male group, the result of regression analysis showed only one statistically significant model. Academic achievement in military theoretical subjects was favored by lower hand tightness, higher body mass index, lower body weight and higher body height. Of course, this was not the expected result; however, the coefficient of determination of this model was only 6.5%, which may indicate randomness, and it is difficult to predict academic achievement from such a result.

With reference to attention, variables measured by the CTT-1 and CTT-2 instruments did not influence the theoretical and practical military competencies. The study was conducted among a heavily selected group of individuals in terms of school performance. Probably because of this, the desired results were not obtained in this area of research.

Additionally, in our research, the results of motor tests indicate a significant advantage of men over women in the level of strength. This is of great practical significance, as in specific military tasks (marching with loads, lifting and transporting heavy military equipment including weapons, ammunition, mines, machines, etc.), strength has a direct impact on the quality of performed tasks. Women are much less able to perform tasks involving the use of force, especially when it is necessary to use force for a longer period. Moreover, as a result of strength-intensive activities, women suffer numerous injuries, muscular pains, and overloading of, e.g., the knee joints and the lumbar spine [35,36,38–40].

With reference to the above results, women performed significantly better in civilian subjects (sciences and natural sciences) (4.02 ± 0.21, $p = 0.0155$), while men achieved

significantly higher results in military (practical) subjects (4.20 ± 0.30, $p = 0.0003$). It is not surprising that men outperformed women in the group of military (practical) subjects, the results of which were directly related to subjects (physical education, shooting training, military topography) requiring physical activity and therefore are directly favored by higher physical fitness.

With the current state of knowledge, the advantage of men over women in muscle strength is well known and results, among others, from a higher accumulation of testosterone, causing the growth and development of muscle mass during sexual maturation in men. Additionally, in muscle building, men have a predominance of type II fast-twitch muscle fibres, as well as a greater ratio of type II muscle fibres to type I. Muscle strength is also associated with somatic development—greater body height and muscle mass, which were characteristic of the men studied [36,40].

Arm strength, which is a measure of the strength of the examined men, is particularly important because its high level is extremely desirable in candidates for professional soldiers. Already at the recruitment stage to military academies in Poland, strength tests are an inseparable element of physical fitness tests for both men and women. Then, in the course of military studies, semester credits include strength tests, starting with hanging on a bar with arms bent, through marching and running with loads and ending with pull-ups on a bar and instrumental gymnastics. An adequate level of strength is a desirable motor ability that has been the subject of much research at other military academies and cadet training centres around the world [41–45]. The presence of strength in the regression analysis can be explained by the need for women to undertake strength training, as they are forced to put the most work into shaping their strength to meet the demands of daily military service. Equally important is one of the didactic rigours required to pass after each semester of military studies, i.e., pull-ups on a bar.

It is interesting to note that the group of subjects whose achievements were affected by strength included only subjects of a theoretical nature, i.e., subjects that are relatively easy to learn compared to practical military subjects. This can be explained by the initial stage of the subjects' training, where practical military skills are only just being taught and require distinctly different competencies than theoretical military or civilian subjects. Therefore, it can be assumed that the impact of physical fitness on practical military subjects may become apparent in the following years of schooling. A breakthrough in this respect may turn out to be the second year of education when a specialist module begins containing a significant number of military specialist subjects, mainly practical ones.

Academic achievements analysed in the study directly represent the level of cognitive functions of cadets, which significantly correlated with physical fitness [16–18]. In our study, the level of attention examined by the CTT-1 test significantly correlated with academic achievements in military (theoretical) subjects in a group of women. The results of studies available in the literature on the relationship between physical fitness and cognitive functions, cited in this paper, concerned mainly soldiers conscripted or in the private corps [25,26,28]. There is a lack of this type of research in the military higher education environment.

Despite the wealth of information on physical fitness and the key role it plays in military life, there is a lack of work in the professional soldier community and particularly in military academies on the relationship between the level of motor skills, somatic development, intellectual fitness and academic and military achievements.

Researchers in military academic centres continuously focus their attention mainly on motor skills, sometimes neglecting the cognitive sphere. This problem should be looked at in the context of specific tasks and competencies required for a given service position in the army. While for a private soldier, the basis is physical fitness, which is needed to perform the basic combat tasks involving mainly highly developed motor components, an officer or commander, in addition to equally high physical fitness, requires above-average cognitive fitness—creativity, focus, multi-tasking, quick thinking, learning, etc. This fitness can be manifested in a variety of ways, such as: the ability to perform a specific task, the

ability to think and learn quickly, the ability to use a variety of methods, and the ability to use a variety of tools. This fitness may be manifested in cognitive activities in which the quality of a decision concerning the execution of a task is important; an example may be a decision when choosing a way to attack an enemy object on the battlefield.

There are some limitations that should be considered when interpreting the results of this study. First, the study was conducted among a heavily selected group of individuals in terms of physical fitness and school performance. In order to be admitted to a military academy, cadets had to have high scores on their high school final exams and go through a demanding admissions process, including physical fitness exams and an interview. Therefore, the results of the study should not be generalized to all students. Moreover, the results of such a selected group of individuals may often not provide the expected results.

Another limitation is that the study was conducted in the early stages of training, at the end of the first semester of study, where differences in physical fitness levels in the context of academic achievement may not yet become apparent. Additionally, as a cross-sectional study, they cannot describe or explain the cause–effect correlation between physical fitness level and attention and cadets' academic achievement. Therefore, the above study will be continued on the same group of subjects in further years of education by the authors of this paper.

In addition, important individual-level factors that may be responsible for part of the correlations between physical fitness and academic achievement, such as cadets' motivation, self-control, individual aptitudes and interests, intelligence level or finally social factors, were not measured.

The small number of women (N = 31) compared to the men participants (N = 197) should also be noted; however, the study group consisted of all cadets enrolled in the first year of study.

6. Conclusions

The results of the research will be used to introduce specialized training aimed at eliminating the biggest differences in physical fitness between men and women by putting more emphasis on the development of strength. Examples include additional physical education classes and training for women only, such as circuit training in the gym with their own body weight, marching with weights, overcoming obstacle courses, and CrossFit. Organized exercises to prevent injuries and trauma-stretching, flexibility and stabilization exercises may also be beneficial. It should be expected that it will result in optimal performance of tasks by both genders during joint tactical exercises in military life [35,36].

Conducting further research among female and male cadets may translate into the optimization of the training process in military academies, which play a significant role in national defence. Moreover, the results of the study will certainly provide further valuable data for researchers dealing with broadly defined physical and mental health.

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9.2. Alternating Attention and Physical Fitness in Relation to the Level of Combat Training

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Alternating Attention and Physical Fitness in Relation to the Level of Combat Training

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Abstract: The level of combat training (CT) of the future commander-leader is of critical importance to the armed forces in national defense. This study aimed to search for the relationship between the level of alternating attention, physical fitness and shooting accuracy (SA), and academic achievements in practical military subjects (PMS). The study group consisted of 137 cadets of the Military University of Land Forces. The measure of alternating attention in the study was the Color Trails Test results. Motor components were assessed by measuring hand static strength, endurance run, and time of a speed and agility run. SA and PMS were taken as measures of cadets' CT. Significantly higher PMS were associated with higher levels of strength and better endurance in cadets. The physical fitness of the cadets did not significantly affect the cadets' SA. The main result of the study is the revelation of the level of alternating attention as a strong determinant of cadets' SA. The authors suggest that the main emphasis should be put on the physical preparation of a modern soldier, focused on the development of strength and endurance skills. It is also reasonable to introduce cognitive stimulation exercises to shooting training.

Keywords: physical fitness; alternating attention; combat training; cadets

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1. Introduction

Armed forces are the basic element of the state defense system, designed for effective implementation of defense and security policies. They take part in the process of stabilizing the international situation, in crisis response and humanitarian operations, supporting internal security and helping society. One of the main elements of evaluating the efficiency and effectiveness of the army is its combat training (CT), which is treated as the ability to perform tasks in the armed forces under conditions of war and peace. The elements of CT consist primarily of the areas of tactical training, shooting, physical fitness (PF), medical training, commanding, topography, battlefield medicine, and mobilization capabilities. CT in peacetime demonstrates the readiness of an army to conduct direct combat in the event of an armed conflict or other crisis, where it will be necessary to use troops. Criteria for the evaluation of CT vary from one army to another and are determined depending on the organizational concept of the armed forces, the level of general and technical culture of the population and the state of health [1]. Despite the current technological progress, modern methods of warfare invariably require a great psychophysical effort from the soldier, so one of the main elements in the evaluation of CT is mental preparation and good PF [2–4].

Nevertheless, important determinants of CT and soldier's readiness to conduct military operations are psychosocial factors, the key to which is a high level of motivation of soldiers and high morale. Most tasks and orders are externally motivated because military service is closely associated with subordination, hierarchy, control, devotion to regulations and rules. This indicates the important role of external motivation for soldiers. However,

internal motivation plays an important role as it drives action even when external motivation ceases. Therefore, it is important for soldiers to feel satisfaction from the action itself, to see the importance of being given orders, to be able to make sacrifices, and even those connected with risking their own health and life. A study by Ryan and Deci (2000) identified three major psychological needs—competence, autonomy, and relationships—which, when satisfied, provide increased self-motivation and mental health. A high level of motivation is extremely important for both rank and file soldiers and command staff to mobilize not only themselves, but more importantly others for commitment, effort, and quality performance [5].

This corresponds with the contemporary concept of health-related fitness, where PF is considered a measure of the body's ability to function efficiently and effectively, to stay healthy, and as a measure of the ability to maintain resilience and cope with crisis situations [6]. In contrast, as Howley and Franks (1977) write, "The goal of PF is positive physical health, which determines low risk of health problems. Performance, on the other hand, aims at the ability to engage in daily tasks with adequate energy and to participate satisfactorily in selected sports" [7].

Combat readiness has always been associated with PF testing in the army. Today, each unit in the armed forces creates its own standard based on different tasks and responsibilities [2]. To perform combat tasks effectively, military personnel need adequate levels of muscular strength, power, agility, coordination, and endurance [8–10].

In addition to physical and mental fitness, shooting training of each soldier is an extremely important determinant of CT. It boils down primarily to effective and accurate shooting at targets with individual weapons (pistols, carbines, selective fire rifles, etc.). Shooting performance may be affected by both physiological and psychological factors [11,12]. Shooting tasks are classified as a complex combat ability that requires the individual to perform multiple motor and cognitive tasks simultaneously (multitasking) or alternate (task switching) between tasks to achieve a given goal [13,14]. Additionally, shooting requires focused attention on the target as well as full control of coordination between postural activity and arm elevation (in the standing shooting stance) [15]. The results of Tremayne and Barry (2001) confirm that both attentional processing and motor preparation are involved in skillful pistol shooting [16]. At the same time, it should be noted that shooting accuracy (SA) largely depends on shooting experience and training [17].

Alternating attention (AA) is one aspect of attention. It is the ability to quickly change attentional focus and shift concentration deliberately from one direction (task, object, activity, etc.) to another without processing all the information coming to us [18]. It is manifested in practice by the ability to possibly shift one's focus from performing one task to another [19], as well as the ability to focus attention and re-engage it in response to external stimuli [18]. AA is examined, among other things, by tests involving tracking and object finding such as the Color Trails Test (CTT) [20], which is a cross-cultural version of the neuropsychological Trail Making Test (TMT).

Analyzing the subject literature, according to our current knowledge, there is a lack of scientific papers in which direct relationships between AA and PF and CT of soldiers (cadets) have been investigated. Therefore, the purpose of this research is to try to find the relationship between the level of AA and PF and CT (SA and academic achievements in practical military subjects (PMS)) in a group of the Military University of Land Forces (MULF) cadets. Thus, the present study appears to be original and novel and its results should be of interest to those interested in military science, national security, shooting, cognitive and PF.

2. Materials and Methods

The study group consisted of cadets—first-year students of MULF in Wroclaw. Cadets are high school graduates who, after successful recruitment to MULF, were called to active military service as candidates for professional officers. While on active military duty, cadets study and receive their education at MULF as a Command Officer Candidate. As a result

of 5-year studies, graduates are prepared to perform tasks in military units, organize and conduct training and educational activities at the platoon level. Cadets at the end of training are promoted to the rank of second lieutenant—the first officer rank of the Polish Army.

The criterion for inclusion in the study was obtaining promotion for the third semester of study and agreeing to informed participation in the study. Initially, 152 men meeting the inclusion criteria qualified for the study. During the course of the study, 15 cadets dropped out of the study by opting out of further military service, wanting to work in another field in the future. Finally, the complete results of 137 cadets were analyzed (Figure 1). The average age of the subjects was 21.03 years. The study was conducted in July 2021 at MULF.

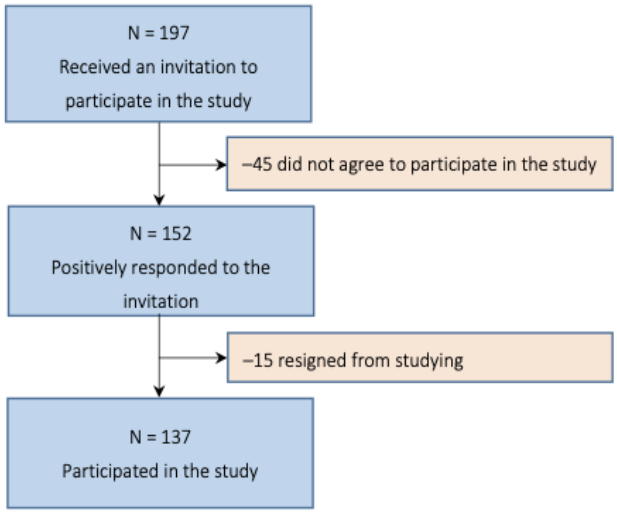

Figure 1. Flowchart of participant enrolment.

The study was designed based on the health-related fitness (H-RF) concept in which health promotion and concern for functional performance and well-being play a key role. Attention was paid to those components of PF that primarily inform health i.e., cardiorespiratory and neuromuscular fitness and muscular strength [6].

2.1. Items by Which Motor Components Were Assessed

a. Dominant hand static strength—hand muscle strength was measured using a Stanley hydraulic hand dynamometer. This is a precise instrument for measuring hand grip strength. The adjustable handle has five settings, allowing you to adjust the device to any hand, regardless of size, measuring up to 90 kg. The measurement was taken with an accuracy of 1 kg. The subject had to clench his hand as hard as he could. The result was read from the hand of the dynamometer, which stopped at the highest reading until zero. The test was performed twice and better result was taken for analysis.

b. The time of the speed and agility run (10 × 5 m shuttle run)—the test was performed in a sports hall. After assuming the starting position in front of the designated line, after the command "START" the examined person ran as fast as they could to the second line, 5 m away, crossing it with both feet and returning. During the run, and especially during the turns, the starters could not support themselves with their hands on the floor. The test was performed once. The time was measured with an accuracy of 0.01 s. Time was measured with a professional hand-held Casio digital stopwatch with an accuracy of 0.01 s from the "START" command to crossing the final line after completing 10 repetitions of the designated 5-m sections.

c. Endurance—the endurance run took place in an athletics stadium. At the signal "READY" the tested person stood behind the starting line in the high starting position. At the signal "START" the participants ran the fastest possible pace to the finish line for 2.5 laps (1000 m). The test was performed in 10-person groups. Time was measured with an accuracy of 1 s.

The study was always conducted by the same team consisting of experienced specialists in human motor skills. The examination was preceded by a warm-up, demonstration, and verbal commentary. PF was assessed based on a test developed by the International Committee for Standardization of Physical Fitness Test (ICSPFT) [21]. PF tests were always performed at the same time of day and in the same place. One day was allocated separately for each PF test, the tests were conducted in the following order: static strength of the dominant hand, 10 × 5 m shuttle run, 1000 m endurance run. Every effort was made to ensure that each test subject had similar testing conditions.

2.2. Alternating Attention (AA)

The measure of AA in the study was the results of the CTT, which is a paper-and-pencil neuropsychological tool designed to test adults aged 18 years and older.

The high validity and reliability of the CTT, as well as the simplicity of its tasks and procedure, combine to make it a particularly valuable tool for diagnosis in clinical psychology, particularly neuropsychology [20,22–24].

The CTT consists of two inseparable parts: CTT-1 and CTT-2, administered to the subject immediately one after the other. Each part contains colored (pink and yellow) circles in which numbers from 1 to 8 (trial) and 1 to 25 (test proper) are placed. In CTT-1, all odd numbers are printed on pink circles and all even numbers are printed on yellow circles. In CTT-2, each number is printed twice, once on a yellow background and once on a pink background. The test task is arranged on a sheet of white paper measuring 21.59 × 27.94 cm^2, with the trial task on the first side of the sheet and the main task on the reverse side [25].

The subject's task was to connect the numbers in straight lines, without taking the pencil off the paper, in ascending order, with the numbers to be connected in such a way as to maintain alternating colors. The beginning and end of the task were marked with graphic symbols. The accuracy of the task and its duration were recorded [22].

Taking into account the differences in the CTT-1 and CTT-2 constructs, the CTT-2 results were used for this study because, unlike the CTT-1, where performance time is a measure of visual search, sustained attention, and graphomotor ability, the CTT-2 results additionally provide information about the divisibility of attention and AA and the ability to process information sequentially. In the context of the CT components examined, the CTT-2 results provide more valuable data.

According to D'Elia and colleagues, performance time indices of the CTT are used to measure functions related to the work of the frontal lobes of the brain. The test is used to examine a variety of processes related to attention and executive functions, specifically assessing intentional material search, sustained and AA, sequential information processing, and monitoring of one's own behavior [20].

The CTT test was administered by a psychologist and took place individually in a lecture room, always under the same conditions and at the same time of day. The time of task completion was measured to the nearest 1 second. The correctness and evaluation of CTT-2 performance was checked twice.

2.3. The Measure of Cadets' Combat Training (CT)

a. Shooting accuracy (SA)

This included the results of two shots at a fixed target; the first consisted in firing from a carbine at a target 100 m away in a lying down shooting stance. The second event involved firing a military pistol at a target 15 m away in a standing stance. The shooter had five rounds and was required to shoot single fire. The maximum number of points it was

possible to obtain was 50. The marksmanship score was the average of the points obtained from the two shooting attempts.

Shooting under the above conditions is primarily used to learn to shoot accurately with the least possible projectile scatter on the target. These tests are usually performed as first tests. They are the initial training for the performance at a later stage of advanced dynamic shooting, with changes of stances, in motion, and under a regime of time and other restrictions. All subjects had the same shooting experience resulting from the same MULF training program. The shootings always took place in similar weather conditions and at the same time of day.

b. Academic achievements in PMS, determined by the average grade at the end of the second semester of training in subjects:
   - Tactics,
   - military topography,
   - physical education.

The grades obtained by students ranged from 2–5, in half grade increments. The mean PMS score was the average of the final semester grades in the three subjects mentioned above.

The explanatory variables were SA (mean score) and PMS (mean score in the subjects). PF components (handgrip strength, speed-agility running, endurance) and attention-related variable (CTT-2) were treated as explanatory variables in this study.

The study was based on the approval of the Rector—Commandant of the MULF (no. 271 dated 18 January 2021) and the consent of the Research Ethics Committee of the Wroclaw University of Health and Sport Sciences (no. 2/2021 dated 12 February 2021). All procedures performed in this study involving human participants were in accordance with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Written informed consent was obtained from all participants included.

3. Statistical Analysis

The collected results were statistically analysed by calculating for all variables: normality of distribution of individual variables was assessed by the Kolmogorov–Smirnov test, relationships between explanatory and explained variables were assessed by Pearson correlation, and relationships between AA and motor components of PF and cadets' SA were analysed by progressive stepwise regression [26,27]. The explanatory variable in the regression analysis was SA (shooting scores), while the explanatory variables were: time achieved in the CTT-2 Color Trails Test, dominant hand grip strength, 10 × 5 m shuttle run time, and 1000 m run time.

Relationships between AA and motor components of PF and PMS were also calculated using progressive stepwise regression. The explanatory variable was PMS, while the explanatory variables were time achieved in the CTT-2 Color Trails Test, dominant hand grip strength, 10 × 5 m shuttle run time, and 1000 m run time. However, none of the explanatory variables entered the PMS prediction model, so the description of the results of this analysis is omitted in the following sections of the paper. The use of the regression method allowed us to determine the optimal set of explanatory variables (including interdependencies between them) that would best predict the performance of the explanatory variable—cadet SA. We chose to include in the model all four explanatory variables analyzed in the study because of the skills desired in military service (strength, endurance, running speed, and agility) and high levels of attention and concentration. Statistical significance in the study, for all tests used, was taken at $p < 0.05$.

All calculations were performed using Statistica v. 13 software from StatSoft in the Laboratory of Biostructure Research of the Wroclaw University of Health and Sport Sciences, certified according to ISO 9001.

4. Results

The basic descriptive statistics of the study group are shown in Table 1. It is noticeable that the results of the dominant hand grip strength test, endurance run, and CTT have the largest standard deviation.

Table 1. Descriptive statistics of the study variables.

Variable	*n*	$\bar{x}$	Reliance −95.0%	Reliance 95.0%	sd	v
Grip strength	137	131.50	128.32	134.67	18.80	14.30
Shuttle run 10 × 5 m		17.98	17.78	18.18	1.20	6.66
Distance run 1000 m		211.42	207.49	215.34	23.23	10.99
Color Trails Test (CTT-2)		59.84	57.72	61.96	12.54	20.95
Academic achievements in PMS		4.17	4.11	4.24	0.38	9.19
Shooting accuracy		35.58	34.60	36.56	5.81	16.34

$\bar{x}$—mean, sd—standard deviation, v—coefficient of variation.

An analysis of the simple relationships between levels of AA and PF with SA and PMS are presented in Table 2. Higher SA was significantly favored by higher AA of cadets. Of note is the relatively high Pearson correlation coefficient (−0.57) indicating a strong relationship.

Table 2. Pearson correlations between the analyzed variables.

Variable	Shooting Accuracy	Academic Achievements in PMS
CTT-2	**−0.57**	−0.07
Grip strength	0.06	**0.18**
Shuttle run 10 × 5 m	−0.05	0.06
Distance run 1000 m	0.15	**−0.24**

Correlation coefficients highlighted in bold are significant with $p < 0.05$.

Among the PF tests, a significantly positive correlation occurred between the dominant hand grip and PMS and a significantly statistically negative correlation between the 1000 m run and cadets' PMS. Significantly higher PMS was associated with higher levels of strength and better endurance in cadets. However, the strength of these correlations was weak.

The results of the regression analysis (using the progressive stepwise method) are presented in Table 3. Finally, only one variable was significantly statistically included in the predictive model of SA—the results of the CTT-2 Color Trails Test ($\beta = -0.566$). The level of AA, examined by the above test, was revealed as a strong determinant of SA, which significantly explains 31.5% of the variability in cadets' SA (adjusted $R^2 = 0.315$).

Table 3. Results of regression analysis (progressive stepwise method) of cadets' shooting accuracy (SA) as a function of their level of alternating attention (AA) and physical fitness (PF).

	Test for Full Model					Standardized Coefficients β for Selected Variables
Variable	F	*p*	Adjusted R^2	SEE	B_0	CTT-2
Shooting accuracy	**63.49**	**0.0000**	**0.315**	**0.071**	**51.27**	**−0.566**

Adjusted R^2—coefficient of determination, SEE—standard error of estimation, B_0—value of the constant, β significant at the $p < 0.05$ level—is indicated in bold.

5. Discussion

There is growing evidence in the literature of the positive relationship between PF, physical activity and aerobic training and academic achievement and more efficient brain

functioning. It has been confirmed in human and animal studies that physical activity, particularly aerobic activity, can have a positive impact on many aspects of brain function and cognition. It can therefore be inferred that higher endurance capacity may contribute to higher academic performance. However, these studies, unlike our own, were conducted on older adults and on animals [28].

In other studies, PF as a construct including attributes related to health and ability has been linked to academic performance in children and adolescents. Of a total of 45 studies included, 25 reported a positive association between PF components and academic performance [29]. Physical activity has been shown to have a positive effect on concentration, memory, intellectual performance, and behavior in primary grades [30], although other studies among secondary school children and adolescents have not found significant correlations. However, a significant limitation of this study was the questionnaire-based assessment of physical activity. Academic performance was assessed by exam scores in English, mathematics, and science, among others [31]. Although the results of the above studies correspond with the results of our own study, it is difficult to make direct comparisons due to the different study groups and the different nature of academic achievement. To the best of our current knowledge, there is a lack of research in the literature on the determinants of academic achievement of student-cadets, where the measure of such achievement is in practical subjects.

The cadets' level of PF expressed in static strength and endurance had a significant relationship with academic achievement in PMS which, along with SA, speak to their level of CT. In contrast, AA was not significant for academic achievement in PMS. Perhaps this is related to the practical nature of the academic achievements included in the study. Indeed, different conclusions spring from the work of Alavi et al. (2019), who found that academic performance in theoretical subjects increased as attention levels increased. However, it should be noted that this study was conducted in a different age group [32].

The results of this study confirm that PF is highly important and desirable among future commanders. Similarly, as indicated by previous studies of Norwegian cadets, the level of endurance and strength of soldiers is of particular importance, ensuring safe and effective performance of physical military work [33]. In this study, a relationship was sought between the results of selected PF tests (push-ups, squats, pull-ups, standing medicine ball throw, and Sargent's jump) and skeletal muscle mass, as a physiological factor responsible for generating maximum muscle power (strength). This factor, in turn, directly affects the effective performance of combat tasks indicative of CT such as evacuation of the wounded, crawling, marches with loads, rapid changes of direction.

Despite the development of modern technologies in military operations, the duties of soldiers constantly consist of tasks requiring high physical effort, such as carrying or lifting heavy loads and materials, prolonged physical effort with additional load and combat equipment, dynamic tactical training or combat shooting. In a study by Pihlainen et al. (2014), the average work intensity in the measured military tasks (e.g., weighted marches, lifting and carrying weights ranging from 10 to 43 kg, digging out a shooting position while lying down), was close to 50% of the soldiers' maximal aerobic capacity, which suggests, similar to the results of our study, that the level of fitness is one of the key components of PF affecting the level of CT. However, it is difficult to directly compare the results of the cited studies with our own results due to the use of different research tools. Additionally, the study was conducted in a group of conscript soldiers and not cadets [8].

In order to effectively perform combat tasks, military personnel need adequate levels of muscular strength and endurance and additionally power, agility and coordination. A study by Kraemer and Szivak (2012) highlights the key role of anaerobic strength training for the demands of the modern battlefield [9]. Strength and endurance exercises are ideally suited for the use of functional actions and movements that reflect combat tasks. Military commanders recognize the need for combat-focused physical training, i.e., programs that target the tasks that can be expected during combat [10,34]. Based on the results of our research, the authors suggest directing the physical preparation of the modern soldier

towards the development of strength and endurance capabilities. It seems that less attention can be paid to the running speed and agility of soldiers.

Researchers from the U.S. military community correctly note that standard military PF tests do not actually test what is needed on the battlefield. In these tests, the main emphasis is on testing endurance levels, while battlefield tasks also require strength [35]. These observations coincide with the results of our work, where, in addition to endurance, strength also significantly correlated with elements of CT of soldiers.

In our study, cadets' SA was not related to their motor fitness. In other authors' studies the effectiveness of shooting was observed after anaerobic exercise [35], overcoming obstacle courses [36] as well as after marching with loads [37]. Upper body movements occurring during breathing significantly impaired the subjects' ability to keep the weapon on target. Moreover, the fatigue of the upper body made it much more difficult to shoot effectively in a standing position. The authors of this study rightly observed that strenuous physical exertion clearly decreases shooting efficiency. Therefore, it should be assumed that the initial higher PF may contribute to the maintenance of the SA level after the physical effort, through a quick recovery after the effort and a smaller decrease of the fitness. Thus, the lack of relationship between SA and motor fitness of cadets from our study may be due to the fact that the shooting was static and not preceded by physical exercise.

Making an attempt to interpret the results, according to our current knowledge, it is necessary to mention the lack of similar studies of the relationship between cognitive processes (including AA) and the level of CT of soldiers including cadets. AA seems to be highly important in achieving high shooting results because a shooter is forced to switch his attention between individual elements important in effective SA (stance, aiming, alignment of aiming devices (bow and pin barrel), simultaneous focus on the target and aiming devices, breathing, pulling the trigger and firing the shot). The results of our study indicate that there is a relationship between the level of attention and SA. Thus, AA may be regarded as a strong determinant of cadets' SA.

However, it seems that other processes related to attention and executive functions, i.e., intentional search of material, sustained attention, sequential processing of information, and self-monitoring, may also be important for high SA. The ability to deliberately and actively select specific data from the environment in shooting comes down to focusing attention only on selected important information (shooting actions, weather conditions, target, weapon) while ignoring other distracting stimuli from the environment (e.g., other shooters and sounds of shots, other external sounds, environment, time) [38].

Maintaining attention in shooting is mainly for focusing on the target for as long as possible. It requires full commitment and concentration on the target. In practice, in case of fatigue or reduced attention, a technique is used in which one stops aiming for a few seconds, directing the gaze to an object of green color, and then returns to aiming with full focus and concentration [39].

Sequential processing of information in shooting is based on the analysis of all the elements in turn, capturing the interrelationships between them, ultimately combined as a set of actions performed to make an accurate shot, e.g., combining the appropriate rhythm of breathing with the simultaneous pulling of the trigger [40].

Monitoring one's own shooting behavior is primarily about controlling emotions. While shooting, one should remain fully focused and calm. Anxiety or stress translates into increased heart rate, increased respiratory rhythm or even muscle tension, which significantly hinders small motor control in shooting activities [41]. Among other things, research confirms that mental fatigue can impair small motor control and affect how shooters respond to targets [42] and the results they achieve [43]. Furthermore, other studies have shown that subtle disruptions in the attention process can lead to dramatic changes in performance [44,45].

Despite the lack of similar studies on the relationship between AA and level of CT, mainly cadet SA, our results correspond with other studies in archery [46] and sport shooting athletes [16]. The results of these studies provided preliminary evidence for the

importance of interoceptive attention in shooting sports and archery [46], and significant narrowing of attention and higher levels of alertness were observed in experienced pistol shooters [16]. However, comparisons with self-reported studies should be made with caution because there are important differences in shooting conditions. Both in archery and in sport shooting there is a different type of weapon and, moreover, shooting is performed in sporting attire, without additional loads such as vest, tactical equipment or helmet.

It seems that the results of our study add to the knowledge concerning the role of attention and concentration in achieving high results in shooting. In fact, earlier studies focused on a group of professional soldiers: marksmen [15] and expert and novice infantry soldiers [41]. It turns out that regardless of the degree of shooting proficiency and the level of CT, attention span and concentration are equally important in a group of cadets (own research), preparing for professional service.

Taking into account the above literature reports, the conditions of the research, its conclusions and the results of our own research it may be concluded that in static shooting in standing and lying postures AA is of particular importance for SA. Therefore, it is necessary to continue the research on the influence of attention-related processes on SA in order to precisely determine which parts of attention have the most significant influence on shooting results in different shooting stances and tasks.

6. Limitations, Strengths and Future Research

The study was conducted among a highly selected group of individuals in terms of PF and academic achievement. Therefore, the results of the study should not be generalized to all civilian and military students. It should also be noted that the measure of cadets' CT in the present study was SA and academic achievement in specific PMS, and did not take into account other components of this training such as medical training, communications, leadership, experience, among others. It is also difficult to directly examine the level of one component of attention because existing neuropsychological tests require the subject to integrate cognitive functions with executive functions (switching, inhibition, working memory) [47].

Since there is a lack of research in the literature on the relationship between AA and PF and cadet CT, this opens up useful new areas of research, especially for researchers in the military community. Other factors (e.g., soldiers' level of motivation or physical activity) potentially important to CT levels would be worth considering in future similar studies. In addition, a lot of valuable information may be provided by the results of future studies on the effectiveness of dynamic shooting under fatigue conditions, as they will more closely match the conditions of combat operations.

7. Conclusions

The level of CT of the soldier (and especially the commander–leader) is of great importance to the armed forces in national defense and should be a key aspiration of every military unit. The readiness of each soldier for warfare is inextricably linked to the level of physical and cognitive fitness. The results of conducted research suggest the necessity of placing great emphasis on the physical preparation of modern soldier, especially focused on the development of strength and endurance capabilities, which have the greatest impact on the level of CT of the soldier. These abilities to the greatest extent reflect the requirements of combat tasks on the battlefield.

Due to the role of effective shooting, the authors also indicate the relevance of introducing cognitive stimulation exercises such as active-response-inhibition training [48] or mindfulness-based attention training [49] to shooting training. This knowledge should be of interest to researchers in the uniformed services community and those professional groups in which weapons are the primary tool of work.

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Data Availability Statement: The datasets used and/or analyzed during this study are available from the corresponding author on reasonable request.

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9.3. Executive Function Level in Cadets' Shooting Performance

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Article

Executive Function Level in Cadets' Shooting Performance

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Abstract: Executive functions (EF) are crucial to a person's unique abilities, enabling one to achieve goals, adapt to new situations and manage social interactions. EF are also very important for the effective performance of military tasks including the shooting performance (SP) of soldiers. The aim of this study was to investigate the association of EF with SP and gender differences in the level of these traits among cadets of the General Tadeusz Kosciuszko Military University of Land Forces in Wroclaw i.e., 156 persons (19 females and 137 males). The level of EF and processes related to attention was measured with usage of the Color Trails Test (CTT-1 and CTT-2). SP was assessed on the basis of scores from four different small arms and rifle shootings at a fixed target and at emerging targets. The relations between explained and explanatory variables were assessed using Spearman correlation. The variation in the mean values of CTT scores and SP of men and women was compared using the Mann–Whitney U test for independent samples. The results of the present study did not reveal any significant differences between women and men in the level of EF and SP. The key finding of the present study is that the higher SP of males in all shooting events of the study and of females in pistol shooting were significantly correlated with higher executive functions.

Keywords: executive functions; shooting performance; gender differences; cadets

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1. Introduction

Executive functions (EF) are processes that allow the control of complex, conscious as well as intentional tasks. Thanks to them, humans are able to monitor and regulate their behaviour and perform so-called intentional activities [1]. These activities are particularly identified with the frontal lobe of the cortex and the cortical–subcortical neuronal network, but other areas are also involved in their regulation, i.e., the dorsolateral prefrontal cortex, anterior cingulate cortex or insula [2,3]. EF include cognitive abilities that enable a person to store information in working memory, inhibit automatic responses to stimuli (inhibitory control) and shift attention between related (attentional shift flexibility) but distinct aspects of a task or problem. Executive abilities, or cognitive control abilities, allow individuals to inhibit behaviors, focus attention and organize thoughts in the face of distraction, task complexity and stress [4].

The level of EF is positively influenced by sports participation. Studies of athletes' brains show that enhanced neuronal networks and plastic changes are induced by the acquisition and execution of complex motor skills during daily intensive physical training. This training often requires rapid stimulus discrimination, specific attention and decision making. It is likely that the mode of neural modulation varies depending on the sport practised. Studies also confirm that open sports (e.g., basketball) can partially compensate for impaired executive control in people with limb impairments by supporting stability of motor responses and fostering flexibility of responses [5,6].

EF are also very important for the effective performance in military tasks performed by soldiers, including shooting abilities [7]. Military personnel are often required to engage

in complex higher order cognitive tasks (working memory, inhibitory control, cognitive flexibility, planning, reasoning and problem solving) [8]. This occurs during physically demanding and stressful military exercises and especially in combat tasks under time pressure and threats to life and health. These tasks may include, but are not limited to, complex topographical orientation, decision making, memorising operational layouts and procedures or performing effective shooting tasks. The ability to maintain a high level of EF is certainly an important element of success among soldiers [9,10].

However, it is still unclear how and whether there are gender differences in the level of EF. Due to methodological variability and the involvement of multiple neuronal networks, it is not possible to make a simple, clear statement regarding differences between men and women in this area [11]. The literature provides divergent information regarding gender differences in CTT performance. Results from a study using the above instrument among 163 healthy participants aged 19–75 years showed a significant influence of age and education level on time to complete both parts of the CTT (higher age and lower education level contributed to slower time to complete both parts), while gender had no effect on time to complete Part B [12]. Data obtained from a U.S. standardized sample (1528 subjects, including 182 African-Americans and 292 Hispanics, ranging in age from 18 to 89 years) also confirm that the influence of gender on CTT scores is not significant; however, increasing age and lower education have been shown to adversely affect performance on this neuropsychological test [13]. Statistically significant differences between men and women were also not found by Konstantopoulos et al. and Hsieh and Tori [14,15]. Contrastingly, in other studies normalizing the Brazilian population, the data on CTT-1 and CTT-2 performance time by men and women were significantly different. Women presented higher mean scores (completion time), which corresponded to poorer performance [16]. Overall, gender does not seem to have a significant effect on CTT results.

Shooting efficiency, together with psychophysical efficiency, makes up the overall combat training of soldiers [17]. It involves accurate, i.e., effective shooting from individual weapons, and is a highly important skill, necessary to be mastered by every soldier. This activity, in connection with weapon handling, requires well-developed small motor skills [18,19]. Shooting is also a closed motor skill [20,21], which requires from a shooter highly developed anti-interference abilities, i.e., focus of attention and high mental intensity. Correct shooting actions (mainly pulling down the trigger tongue and maintaining a stable stance) are particularly associated with high demands on executive and inhibitory functions. In addition, the shooter updates his current behaviour with previous experiences in order to achieve a high score in the shooting task [22].

Often when shooting, shooters are exposed to stressful situations, e.g., during competitions, military exercises, difficult weather conditions or, finally, in warfare. In such situations, executive processes must occur at the highest level; this is necessary for the effective performance of the task [7,23,24]. During the firing of a shot it is also important to focus on the target, with simultaneous control of the body posture and such a positioning of the fingers to keep control over the trigger of the pistol. For this reason, both cognitive abilities and vigilance as well as appropriate motor skills are necessary to make an accurate shot [25]. For this to happen, alternating attention, which is one of the components of attention as a cognitive function, is also of considerable importance. Thanks to it, the shooter can control and coordinate all the activities mentioned above [26].

Various determinants of SP are sought in research; one of them is gender. Reports from the literature on gender differences in SP are divergent on this issue [27,28]. In a study by Kemnitz et al., female and male soldiers did not differ in their SP, although the men in the study sample had significantly less body fat, slimmer arms and were generally physically stronger than the female participants [29]. In the authors' subsequent study, no significant differences were again found between male and female soldiers in accuracy or shooting precision, although it was initially suspected that this difference might be due to the size of the weapon (carbine weight and barrel length), which might be worse for women with less

arm strength. As it has been proved, the above parameters proved to be significant for SP, however, irrespective of the gender [27].

Research on gender differences in SP has also been conducted in groups of athletes, where a good opportunity is a championship competition such as the European Championships. Mon-López et al. similarly showed no significant differences in SP in both rifles and air pistols. The lack of significant differences, according to the researchers, confirms that physical strength is an insignificant factor influencing performance in sport shooting, so the determinants of SP should be sought in other factors, perhaps in the shooter's cognitive performance zone [30]. SP was also analysed after intensive exercise and caffeine consumption among reservists, where again no gender differences were found [31].

Gender differences in SP are extremely important in the police community where effective skill in the use of a personal weapon can often be decisive for one's own and others' safety. In fact, police officers may find themselves in a situation of direct danger on any duty day. Contrasting with the above literature reports, the results of studies in these populations indicate that male police officers shoot more effectively with handguns compared to females. The main factor attributed to the above differences is grip strength, which is potentially important to pistol shooting accuracy [28,32].

In another study, Johnson and Merullo showed that while men maintained the same accuracy during 3-h sentry sessions, accuracy in women deteriorated after 1.5 h. The shooting sessions consisted of detecting and shooting at targets that appeared infrequently [33]. In a recent study by Mon-López et al. comparing the performance of 704 shooters who participated in the recent World Shooting Championships, it was shown that men's performance in pistol shooting was better than the performance of women. However, men and women performed the same in the overall analysis, while their performance differed by category and competition [34]. Researchers have also mainly focused their attention on rather obvious differences in physical factors such as upper body strength, grip strength, balance and coordination, important for high SP, neglecting the shooter's cognitive abilities, which are potentially important [32].

To our current knowledge, the available literature does not provide sufficient information on the link between EF and SP. The issue of gender differences in the level of EF as well as differences in soldiers' SP also requires supplementation and continuous analysis. The present study may therefore complement the literature with research in military populations. At the same time, the importance of conducting scientific research in the group of soldiers is emphasized, as the results may be particularly important from the point of view of benefits for national defence. The aim of this study was to investigate the association of EF with SP and gender differences in the level of these traits among cadets of the General Tadeusz Kosciuszko Military University of Land Forces in Wroclaw (MULF). We hypothesized that regardless of gender, cadets' SP level would be related to their EF level.

2. Materials and Methods

The study group consisted of cadets—first-year students of the MULF. Cadets were in the course of their candidate military service and after 5 years of training they will start their professional military service. The main effect of education at MULF is the possession of appropriate knowledge and competences by graduates required to take up their first command positions in the officer corps.

The criterium for inclusion in the study was obtaining promotion to the third semester of study. The respondents gave written, informed consent to participate in the study and were fully informed about the purpose of the study. Initially, 172 cadets fulfilling the study inclusion criteria were enrolled in the study. During the course of the study, 16 cadets dropped out of the study as they opted out of further military service. Ultimately, 156 individuals (19 females and 137 males), i.e., all cadets meeting the inclusion criteria, were included in the study. The study was conducted at the MULF in the period May–July 2021 (Figure 1).

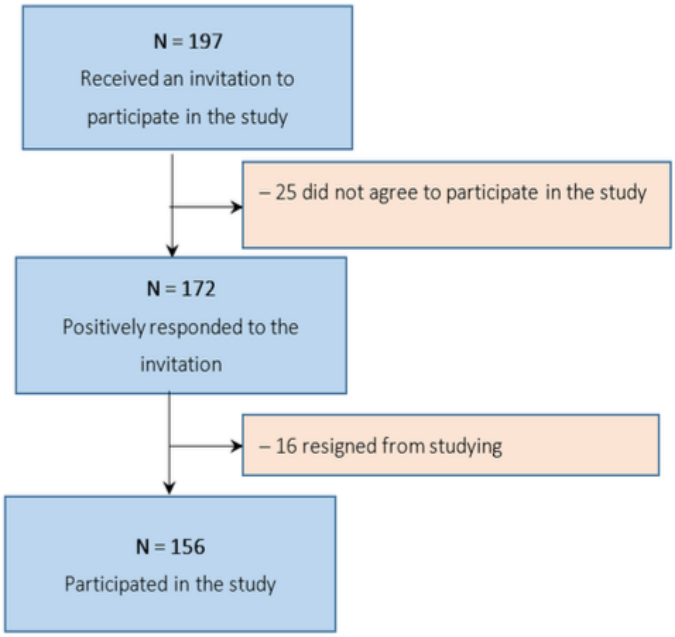

Figure 1. Flowchart of participant enrolment.

3. Executive Functions

Measures of the level of EF and attention-related processes were the results of the Color Trails Test (CTT-1 and CTT-2). The Color Trails Test contains numbered coloured circles and language symbols with wide cross-cultural applicability (no language influence). The colours used in the CTT are universal. The visual stimuli in the CTT are circles with the numbers 1 to 25 written in the middle. Each circle is coloured yellow or pink. These colours are also seen by people with colour blindness. In the first part of the test (CTT-1), all odd numbers are in the pink circles and all even numbers are in the yellow circles. In the second part of the test (CTT-2), each number is printed twice, once in a yellow circle and once in a pink circle. The CTT sheets are printed on white paper measuring 21.59 × 27.94 cm. The universality of the CTT is due to the use of numbers and colours as symbols, with little involvement of speech and knowledge. The CTT is intended for adults (18+) and is designed to avoid making correct performance dependent on the knowledge of any alphabet and, to the greatest extent possible, on the influence of language [13,35].

The CTT-1 asks the participant to connect the circles in order from 1 to 25 with a rope as quickly as possible without taking the pencil off the paper. Before proceeding to the main task, the subject performs a trial task as fast as they can. The measure of the CTT performance is the time (in seconds) to correctly complete the task of connecting all circles from 1 to 25. The time is measured from the moment the test subject brings the pencil close to the first circle (starts the test). The stopwatch switches off as soon as the test subject touches the outer edge of the last circle with the pencil. In CTT-2, the tested person is asked to line up the numbered circles as fast as possible, taking into account the condition of colour alternation (pink circle 1, yellow circle 2, pink circle 3, etc.). As in CTT-1, a test task is performed before the main task.

The study was carried out among healthy individuals with no diagnosed clinical problems. Temporal indices of CTT performance are used to measure functions related to frontal lobe brain function. In interpreting the CTT results, a variety of processes related to attention and EF were examined, and, in particular, intentional search for material,

sustained and metastable attention, sequential processing of information and monitoring of own behaviour were assessed [26].

The CTT was performed by a psychologist, took place in a lecture room, always under the same conditions (psychologist–subject) and at the same time of day. The time of task performance was measured with an accuracy of 1 s. The correctness and evaluation of the CTT performance was checked twice.

4. Shooting Performance

SP was assessed on the basis of the results of four different small arms and rifle shootings at fixed and emerging targets:

1. Rifle Shooting (RS)—consisted of shooting from a rifle in a lying position with the use of a stand on a stationary target 100 m away. The shooter had 5 cartridges and his task was to shoot with single fire. Accuracy and focus were important in this test. The score was determined by a number of points ranging from 0 to 50.
2. Shooting with a military pistol (PS)—this consisted of shooting from a military pistol in a standing stance at a stationary target 15 m away. The shooter had 5 cartridges; his/her task was to shoot with single fire; the shooting was performed with accuracy and focus. The score was determined by a number of points from 0 to 50.
3. Machine Pistol Shooting (MPS)—on the command "forward" the shooter marched or ran 10 m from the starting line to the firing line, assumed a shooting stance, prepared to fire and then began shooting. The first target was sighted 30 s after the command "forward" was given. The target appeared 5 times at a distance of 75 m. The time for each target to appear was 30 s. The interval between target appearances was 10 s. The score was determined by the number of hits on the target (score 5—4 hits, score 4—3 hits, score 3—2 hits).
4. Shooting from a rifle in a gas mask (RSG-M)—on the command "forward" the shooter marched or ran 10 m from the starting line to the firing line, assumed a shooting stance, prepared for shooting and then, after the first target appeared, started shooting. The first target appeared 30 s after the command "forward" and shooting was in short bursts while lying down with support. The target appeared 5 times at a distance of 100 m. The time taken for each target to appear was 30 s. Intervals between target appearances lasted 10 s. The shooter performed all actions in a gas mask. The score was determined by the number of hits on the target (score 5—4 hits, score 4—3 hits, score 3—2 hits).

All subjects had the same shooting experience resulting from the same military uniform training program. Every effort was made to ensure that shooting always took place in similar weather conditions and at the same time of day. The basis for conducting the tests was the consent of the Rector—Commandant of the university (No. 271 of 18 January 2021) and the consent of the Senate Committee on Research Ethics of the University of Health and Sport Sciences in Wroclaw (No. 2/2021 of 12 February 2021). All procedures performed in this study involving human participants were in accordance with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Written informed consent was obtained from all participants included.

5. Statistical Analysis

The collected results were subjected to statistical analysis. The normality of the distribution of individual variables was assessed using the Kolmogorov–Smirnov test. Of the variables analysed, the normal distribution was held by the shooting scores from all the shootings from the study in the women's group and the scores from all the shootings and the time achieved in the CTT-1 in the men's group. Non-normal distribution had CTT-1 and CTT-2 test scores in the female group and CTT-2 test scores in the male group.

The relationships between the explained and explanatory variables were evaluated using the Spearman correlation because not all variables analysed in the study had normal distributions. The correlation of each individual shooting score with CTT test scores was

evaluated separately due to the different shooting conditions of the individual shooters and the different types of weapons. Different battlefield situations force a soldier to perform different shooting tasks, from shooting on full rest without additional stressors to shooting under conditions of very high physical effort, limited visibility or under time and danger regime. The different results of the correlation analysis are, in a way, a confirmation of the validity of this choice. This is because the authors wanted not only to see if there were relationships between EF and SP, but also to try to determine precisely whether, if such relationships existed, EF equally affected each shooting modality of the different weapons. The variation in mean values of CTT scores and SP of men and women was compared using the Mann–Whitney U test for independent samples.

Statistical significance was assumed at the level of $p < 0.05$ for all the applied tests. Calculations were performed using Statistica v. 13.1 software by StatSoft (Wroclaw, Poland)in the Biostructure Research Laboratory of the University of Health and Sport Sciences in Wroclaw, certified according to ISO 9001.

6. Results

The variation in the mean values of the tested variables by Mann–Whitney U test is presented in Table 1. As a result of the analysis, no significant differences in the mean CTT scores as well as in the SP of individual shooters were found between men and women. However, when comparing the mean scores of males and females, a lower arithmetic mean of the times achieved in CTT-1 and CTT-2 as well as higher SP in three out of four shooting events among females was observed. However, as mentioned above, these differences were statistically insignificant, so they can only be treated as a trend requiring possible further confirmation in subsequent studies.

Table 1. Variation in mean CTT scores and shooting performance by Mann–Whitney U test for independent samples between men and women. Variation coefficients in bold are significant with $p < 0.05$.

Variable	Men (N = 137)			Women (N = 19)			U Mann–Whitney Test
	$\bar{x}$	sd	v	$\bar{x}$	sd	v	p
Age (years)	21.03	1.31	6.22	21.15	1.08	5.11	0.3683
Body height (cm)	179.17	5.58	3.11	167.27	4.40	2.63	**0.0000**
Body mass (kg)	76.82	7.69	10.01	61.83	3.41	5.52	**0.0000**
CTT-1 (s)	31.12	7.99	25.66	28.58	10.68	37.37	0.2105
CTT-2 (s)	59.84	12.54	20.95	58.74	11.11	18.92	0.8550
RS (score)	36.64	5.90	16.10	36.16	5.74	37.37	0.4255
PS (score)	34.53	8.63	24.99	35.53	9.32	18.92	0.5576
MPS (grade)	4.46	0.84	18.84	4.89	1.13	15.87	0.0651
RSG-M (grade)	4.39	0.93	21.08	4.79	0.32	26.24	0.0745

RS—rifle shooting, PS—pistol shooting, MPS—machine pistol shooting, RSG-M—shooting from a rifle in a gas mask.

The analysis of simple correlations between the level of EF and attention-related processes and the SP of male and female cadets is presented in Table 2. Of the four shooting events, only military PS was found to be statistically significantly negatively correlated with CTT-2 scores. Higher military PS scores were significantly associated with shorter CTT-2 performance in the female group. Such a high correlation coefficient ($r = -0.76$), indicates a very strong interdependence of the studied variables. The remaining correlations in the female group were statistically insignificant.

Table 2. Spearman correlation results between the study variables. Correlation coefficients in bold are significant with $p < 0.05$.

Variable	Men		Women	
	CTT-1	CTT-2	CTT-1	CTT-2
RS	**−0.23**	**−0.47**	−0.20	−0.35
PS	−0.10	**−0.51**	−0.21	**−0.76**
MPS	−0.13	**−0.39**	−0.16	0.28
RSG-M	−0.03	**−0.18**	−0.11	−0.28

RS—rifle shooting, PS—pistol shooting, MPS—machine pistol shooting, RSG-M—shooting from a rifle in a gas mask.

In the men's group, higher SP in RS was significantly correlated with shorter CTT-1 time. This is evidenced by the negative correlation coefficient, but the strength of these correlations was weak (r = −0.23). The results from the other shootings in the male group were not significantly correlated with the time achieved in the CTT-1 attention test. The correlation results, however, revealed mutual correlations between all the shooting results from our study and the time achieved in CTT-2. SP appeared to be significantly negatively correlated with CTT-2 performance, so in the male group, higher SP was significantly correlated with shorter CTT-2 performance time. Strong correlations occurred between RS (r = −0.47) and PS (r = −0.51) and CTT-2 performance. The correlation between MPS performance and CTT-2 time was at the average level (r = −0.39). A weak but also significant correlation occurred between RSG-M scores and time in the CTT-2 (r = −0.18).

7. Discussion

EF help to resist strong internal tendencies and external stimuli, including controlling attention, behaviour, emotions and thinking, and focusing on ongoing action to make appropriate behavioural decisions [36]. The results of our study did not reveal significant differences between women and men in the level of EF. The literature provides divergent information regarding gender differences in CTT performance. Statistically significant differences were not found by Konstantopoulos et al. or Hsieh and Tori [14,15]. Different data were presented by Rabelo et al., who obtained a statistically significant difference in favour of men [16]. In another study, Gaillard et al. conducted a systematic review of the literature aimed at summarising the current evidence on sex differences in three domains of EF: performance monitoring, response inhibition and cognitive set-shifting using functional neuroimaging tools (fMRI, PET, EEG and NIRS). A meta-analysis of 21 studies, involving a total of 677 women and 686 men, indicated that due to methodological variability and the involvement of multiple neuronal networks, it was not possible to provide a simple, binding statement on the differences between men and women in levels of EF. However, there is now evidence of sex differences in the neural networks underlying all EF considered in this review, suggesting that men and women use different strategies depending on the demands of the task. However, functional neuroimaging, although a highly detailed and valuable study, may not be sufficient to identify sex differences in the level of EF, so work using neuropsychological tests such as the CTT may complement the above studies [11].

Comparative value with the results of our own research in the context of gender differences in the level of EF is provided particularly by data from standardisation trials for the CTT. The results of the American standardisation trial among 1531 individuals (male = 1345, female = 183) confirmed that, regardless of age group, no gender factor influence on CTT scores was found. It should be noted that women in this sample constituted 12% of the total study population, as in our study [13].

On the other hand, in other studies normalizing the Brazilian population, the data on CTT-1 and CTT-2 performance time by men and women were significantly different. Women presented higher mean scores (completion time), which corresponded to poorer performance [16]. A subsequent study among a Greek population of healthy subjects (men = 79, women = 84) showed little effect of gender on CTT-1 performance time (women performed relatively worse compared to men). This contradictory finding compared to the

results of our own study may be attributed to the fact that women in the above studies had lower levels of education compared to men [14]. The literature confirms that education has a significant effect on the level of EF tested by the CTT test [16,37]. In our study, men and women represented the same level of education resulting from the same educational program. It should additionally be noted, as is usually the case with normative research in studies, the participants were from a wide age range, while in our study the study group was a first-year military community in the age range (20–26 years).

Studies in military settings confirm that men perform better in military tasks, especially those requiring prolonged use of strength and endurance [38,39]. However, it is still not entirely clear whether gender differences are equally obvious in such specific tasks as shooting. Shooting is one of the most important skills indicative of a soldier's preparedness, which translates into the combat capabilities of a military unit. Since women began to join the ranks of armies in various countries, a discussion has begun about their role in combat operations. Researchers began to focus their attention mainly on rather obvious physiological differences, neglecting cognitive abilities and various elements of combat training including shooting efficiency. According to our current knowledge, the literature on the subject is quite poor in cross-gender comparative analysis of soldiers in terms of SP. In our study, no significant differences in shooting efficiency were observed between men and women. Despite the fact that in three out of four shootings women achieved slightly better results, these results were not statistically significant. Similar results were observed in their study by Kemnitz et al., who evaluated the effect of gender on shooting accuracy in a group of 15 male and 13 female soldiers. The Noptel simulator was used to assess accuracy (distance of shots from the centre of the target) and precision (distance of shots from each other regardless of distance from the centre of the target). As in our own study, no significant differences were found in any of the measures of SP according to gender. Although the above results confirm the reports from our own study, it should be noted that it was conducted under different shooting conditions. The main difference consisted in shooting from a simulator, whereas the shooting in our study took place on an open range; additionally, different weapons were used and different targets were shot at different distances. However, it can be concluded that women and men do not differ in SP regardless of the different shooting conditions [27].

In another study involving 292 shooters who competed in the 2016 and 2018 European Championships, men and women shot equally well with rifles, and although men's average pistol scores were higher than women's, the difference was not statistically significant. It was concluded that in sports where physical strength is a less important factor, as in the case of sport shooting, the rules should be revised for greater gender equality [30]. The above results are consistent with those of our own study, but the fundamentally different shooting conditions and the different type of weapons should be noted. In the study cited above, participants dressed in a special shooting suit shot with an air rifle, whereas in our study soldiers shot with firearms in tactical gear. In contrast, a study by Goldschmied et al. found no differences in the performance of men and women in shooting either an Olympic air rifle or a 22 caliber rifle in shooting competitions. The authors justify this on the grounds that "in shooting, the physical demands on athletes are relatively low". The study by Goldschmied et al. corresponds with the results of our own study confirming the lack of significant differences in SP among both shooters with low shooting experience and at the highest competitive level [40].

Interesting results were presented by Vučković et al., who, in a group of male and female police officers, determined the effectiveness of a basic training program in the use of small arms. During the three stages of the study, i.e., at the beginning, in the middle and at the end of the shooting training, significant differences in SP between men and women emerged only at the beginning of the training. Moreover, the same shooting training program increased the final SP by 136.43% among women, while the increase was 45.69% among men. Thus, the above results confirm that women do not differ from men in SP in both long and short arms [41].

However, some studies report gender differences in small arms SP. Anderson et al. found that male police officers performed better with pistols than female police officers [32]. Similar results were obtained by Copay et al., who observed that males performed better than females in shooting 9 mm, 0.40 inch (.40 Smith & Wesson) and 0.45 inch (.45 Automatic Colt Pistol) pistols [28]. The different shooting effects are attributed to the difference in grip strength, although its effect on SP was small. The results of our own study also do not agree with other studies that found that men performed better than women in shooting with 22 caliber rifles at a distance of 50 metres [42] and in military conditions with rifles [33]. The military study, unlike our own work, was conducted on a Weaponer simulator. The results of this study showed that during the first 1.5 h of guard duty, women shot as accurately as men. It was only after 1.5 h that their rifle shooting accuracy deteriorated and they did less well with accurate shots on target, with no deterioration in reaction time in the form of detecting the target and firing the shot. According to the authors, this difference may be due to gender differences in hand stability or to possible weaker upper body strength (causing greater fatigue after a longer duration of the combat task). However, both hypotheses are speculative and require further research.

It seems crucial to note in our study that the higher shooting scores achieved by males in all shooting tasks of the study and by females in PS were strongly significantly associated with higher EF. The strongest significant correlations occurred in carbine and pistol shooting in the male group, which was probably caused by the shooting conditions consisting in firing at a fixed target with accuracy and focus without a time regime and on full rest. A weaker correlation occurred in the machine pistol shooting, in which there was another stress factor of moving quickly to the shooting position and the target appearing in a limited time, which was undoubtedly a big limiting factor for the shooter [7]. These factors revealed that in more dynamic shooting, further variables related to SP, such as physical fitness, are likely to emerge alongside EF.

The weakest significant correlations occurred in shooting after rapid movement to the shooting position, in shooting under the regime of target appearance time and probably due to the gas mask worn during all activities. The gas mask makes it very difficult to fire effectively; it sometimes fogs up during physical exertion and shooting, which impedes the visibility of the target and aiming devices, has a limited field of vision and significantly impedes the acquisition of a comfortable and appropriate shooting stance (head position in relation to the weapon) [43].

The strongest significant effect of EF on SP was revealed in military pistol shooting in both the male and female groups. This shooting was performed on accuracy and focus in a standing stance. It was by far the easiest or one of the easiest shootings of the test, as the distance to the target was only 15 m and the target at which the fire was conducted was the same as in the carbine shooting at a distance of 100 m. Of course, small arms were fired, but the very short distance to the target made it more "forgiving" of possible shooter errors [30]. The lack of significant correlation between CTT-1 performance time and SP, except for carbine shooting in the group of males where the strength of correlation was weak anyway ($r = -0.23$), clearly indicates that the second part of CTT, i.e., CTT-2, should be used to study complex performance functions with a potential relationship to the SP of soldiers [13].

Since males and females did not differ in their level of SP, and among males all shootings were positively associated with shorter CTT-2 performance, the lack of significant correlations in three out of four shootings with CTT-2 performance time in the female group can be explained by their small numbers. It can also be assumed that the remaining correlations would probably have been revealed if the number of women had been similar to the number of men. However, the study included all women who studied at MULF.

The literature recognizes that military performance depends on high levels of cognitive, EF, especially during heavy physical exercise [7]. Associations of some EF with SP among soldiers were found, among others, by Hillman et al. They examined EEG activity during the preparation period between executed and rejected shots to better understand

the attentional processes associated with the pre-shooting state. As in our study, they recognised the large role of attention in the complex process of firing a shot. Additionally, it was found that the decision to reject a shot appears to be characterised by a misallocation of neural resources associated with task performance. The study, unlike our own research, was conducted on a group of skilled sharpshooters who performed shooting at much greater distances than cadets, so comparisons should be made with caution [25].

Additionally, the results of our own research confirm the recent study by Shao et al. in which it was reported that self-control (as one of the elements of EF) during the performance of closed motor tasks in the environment determines that shooters have a higher anti-interference ability. This ability, in turn, boils down to the deliberate and active selection of specific data from the environment in shooting, i.e., focusing attention only on selected important information while ignoring other distracting stimuli from the environment [22]. Furthermore, the work of Sattlecker et al. focused on athletes at World and European Cup level in biathlon showed that postural balance and rifle stability play a key role in this sport [44]. Studies on such a skilled shooting group prove that shooters must be strongly engaged with the target while aiming and working on the weapon (attentional control) and constantly monitoring their behaviour and controlling their emotions to minimise the risk of making a mistake. On the other hand, when a mistake is made, they should make sure it has as little impact on the result as possible. For example, if a mistake occurs in the form of a "missed shot", i.e., a trigger pull that is too fast, the shooter should quickly and accurately identify the problem, which is related to the control of emotions, and then make the appropriate correction and prevent a similar mistake from being repeated in the future (behavioural control). Comparing the above study with the results of our own research, it should be noted that the shooting was performed indoors at a distance of 50 m with a specialised air rifle fitted individually to each athlete without any additional physical load. Military shooting, on the other hand, usually involves an additional mental and physical load, so the greater use of EF in the form of behavioural control, emotions, focus of attention and the ability to eliminate external stimuli may be key determinants in SP.

Our results also show that the strength of the correlation between SP and the level of EF decreased with the more difficult level of shooting (shooting after a run-in and in a gas mask). This was probably related to a decrease in the level of EF under the influence of a greater external stressor such as a short and quick change in shooting stance, a gas mask and targets appearing in a limited time. The above results correspond with those of previous studies on EF at specific exercise intensities. Labelle et al. observed a significant decrease in EF at both 60% and 80% of peak power output [45]. Furthermore, Lo Bue-Estesa et al. confirmed that EF decreased during post-exercise assessment [43]. Additionally, the results of our own study are consistent with the results of a study among Reserved Officer Training Corps (ROTC) cadets, in which it was proven that high-intensity exercise decreases EF [7].

The results of our study confirm the hypothesis that gender is not a significant factor that affects the level of EF and the SP of soldiers. A higher level of EF has a significant effect on higher SP of male soldiers in all types of shooting from the present study with both carbines and pistols. However, among females, higher EF has a significant effect on higher pistol SP.

Summarizing the results of our own research and from the literature reports on gender differences in SP, it can be noted that there are still many unexplained issues. Noticeable discrepancies may be a result of differences in the way SP is measured in individual studies, the degree of shooting difficulty and natural somatic and motor differences. Therefore, it seems reasonable to systematically examine the SP of soldiers in a way that most accurately reflects the requirements of the population of interest, in particular, the study of soldiers' actions in real combat and training ground conditions. The level of shooting training of an individual soldier and his cognitive efficiency (especially of a commander–leader) is of great importance for the combat potential of the armed forces and should be a key aspiration of each military unit. The results of the conducted research as well as many other

works confirm the necessity of placing great emphasis on the cognitive preparation of a modern soldier, in particular aimed at the development of EF skills. They have a significant impact on the level of a soldier's shooting efficiency.

8. Limitations, Strengths and Future Research

The upper or lower values for some variables are due to hazard. This is the meaning of statistics when $p < 0.05$. Significant relationships and differences were shown on a sample with small numbers of women relative to men. We saw significant relationships between the variables studied, or lack thereof, but our evidence is weak because we showed them on a small number of subjects relative to men. Thus, we are not entirely sure that what we see is not a coincidence (which is always easier the smaller the sample), and that we will see a strong relationship again when we repeat this experiment; so more research is needed. In contrast, we saw strong evidence in statistically significant correlations in a large group of men.

Due to the simplicity of application in a military setting, the level of EF and processes related to attention were assessed using the Color Trails Test (CTT-1 and CTT-2). Despite the great popularity of neuropsychological tests for the assessment of EF in research (CTT, Wisconsin Card Sorting Test, Stroop Test) [46,47], it is now also possible to assess EF using neurophysiological methods such as visual or auditory evoked potentials and gamma oscillation. Increasingly, high-tech neuroimaging methods are also being used for neurocognitive measurements.

There is a lack of research in the literature on the relationship between EF and cadet SP, so this opens up useful new areas of research, particularly for researchers from the military community. Further research would be worthwhile to consider other factors influencing SP (e.g., type of shooting training, kinematic analysis of shooting stance and weapon stability, physical fitness) potentially important for the level of shooting training. Moreover, a lot of valuable information may be provided by the results of future research on dynamic SP under conditions of higher physical and mental fatigue in both male and female groups, as they will be more relevant to the realities of combat operations.

9. Conclusions

EF are crucial to unique human abilities including, as it turns out, soldiers' SP. A more thorough analysis of the components of EF may help to develop targeted interventions to improve them. This knowledge should be of particular interest to researchers in the uniformed services community and those professional groups where weapons are the primary tool.

The results of our own research indicate that female cadets represent a similar level of EF as well as SP; therefore, the load and evaluation methods in training should not be differentiated by gender. However, the problem of gender differences in specific professions such as uniformed services remains open and requires further detailed analysis.

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10. Załączniki

10.1. Zgoda Senackiej Komisji ds. Etyki Badań Naukowych

2/2021

Senacka Komisja ds. Etyki Badań Naukowych przy Akademii Wychowania Fizycznego we Wrocławiu

Uchwała
w sprawie opinii o projekcie eksperymentu poznawczego

Na podstawie uchwały Senatu Akademii Wychowania Fizycznego we Wrocławiu z dnia 20.12.2002 r. w sprawie powołania Senackiej Komisji ds. Etyki Badań Naukowych i uchwały z dnia 4.11.2003 r. – regulamin działań oraz w oparciu o art.27 ustawy z dnia 6.06.1997 r. kodeks karny (Dz.U. z 1997 r., poz.553 z późniejszymi zmianami) i zasady zawarte w „Dobrych obyczajach w nauce. Zbiór zasad i wytycznych" Komitetu Etyki w Nauce PAN z 2001r.

Przewodniczący Senackiej Komisji ds. Etyki Badań Naukowych przy Akademii Wychowania Fizycznego we Wrocławiu po zapoznaniu się z opinią Członków Komisji Etyki wniosku złożonego przez Pana:

mgra Dariusza Jamro

pt. „Poziom sprawności fizycznej a sprawność uczenia się oraz opanowania umiejętności wojskowych kandydatów na żołnierzy zawodowych, studentów Akademii Wojsk Lądowych imienia generała Tadeusza Kościuszki we Wrocławiu"

podjął decyzję o pozytywnym zaopiniowaniu tego wniosku, nie wnosząc żadnych zastrzeżeń.

Wydana opinia dotyczy tylko rozpatrywanego wniosku z uwzględnieniem przedstawionego projektu. Każda zmiana i modyfikacja wymaga uzyskania odrębnej opinii. Wnioskodawca obowiązany jest do informowania o ciężkich lub niespodziewanych zdarzeniach, niepożądanych i nieprzewidzianych okolicznościach, o zakończeniu badania, o jego wynikach i innych istotnych decyzjach ewentualnych innych komisji etycznych (bioetycznych).

Od powyższej uchwały podmiot zamierzający przeprowadzić eksperyment, kierownik jednostki organizacyjnej, w którym eksperyment poznawczy ma być przeprowadzony oraz komisja etyczna (bioetyczna) właściwa dla ośrodka, który ma ewentualnie uczestniczyć w wieloośrodkowym eksperymencie, mogą wnieść odwołanie do Zespołu Opiniodawczo-Doradczego do Spraw Etyki w Nauce Ministerstwa Nauki i Informatyzacji, za pośrednictwem Senackiej Komisji ds. Etyki Badań Naukowych przy Akademii Wychowania Fizycznego we Wrocławiu w terminie 14 dni od daty otrzymania niniejszej uchwały.

Przewodniczący Senackiej Komisji
ds. Etyki Badań Naukowych

Wrocław, dnia 12.02.21

Prof. dr hab. n. med. Marek Mędraś

10.2.Oświadczenia o współautorstwie

Oświadczenie o współautorstwie

dr hab. Grzegorz Żurek, Prof. AWF
Zakład Biostruktury
Akademii Wychowania Fizycznego i Sportu we Wrocławiu

Wrocław, 09.01.2023 r.

Oświadczenie o współautorstwie publikacji

Niniejszym oświadczam, że w pracy (*Jamro, D.; Zurek, G.; Lachowicz, M.; Lenart, D. Influence of Physical Fitness and Attention Level on Academic Achievements of Female and Male Military Academy Cadets in Poland. Healthcare (Basel) 2021, 9 (10), 1261)* mój udział polegał na:

[X]	koncepcja pracy	[X]	redagowanie publikacji
[X]	zaplanowanie badań wybór metodyki	[X]	zbieranie danych
[ ]	prowadzenie badań	[ ]	graficzne przedstawienie wyników
[ ]	analiza statystyczna	[ ]	zbieranie piśmiennictwa
[X]	interpretacja wyników i opracowanie wniosków	[X]	korekta pracy przed złożeniem do druku
[X]	konsultacja	[X]	inne: walidacja

Przyjmuję do wiadomości, że powyższa praca jako część rozprawy doktorskiej będzie podstawą do ubiegania się o nadanie stopnia doktora przez mgr. Dariusza Jamro.

Podpis współautora

Oświadczenie o współautorstwie

dr hab. Grzegorz Żurek, Prof. AWF
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[X] koncepcja pracy	[X] redagowanie publikacji
[X] zaplanowanie badań wybór metodyki	[X] zbieranie danych
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[X] konsultacja	[X] inne: walidacja, nadzór,

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Podpis współautora

Oświadczenie o współautorstwie

dr hab. Grzegorz Żurek, Prof. AWF
Zakład Biostruktury
Akademii Wychowania Fizycznego i Sportu we Wrocławiu

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Grzegorz Żurek
.....
Podpis współautora

Oświadczenie o współautorstwie

ppłk dr Dariusz Lenart
Kierownik Zakładu Wychowania Fizycznego i Sportu
Akademia Wojsk Lądowych im. generała Tadeusza Kościuszki we Wrocławiu

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Podpis współautora

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Małgorzata Dulnik
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Podpis współautora

Oświadczenie o współautorstwie

Małgorzata Dulnik
Akademii Wychowania Fizycznego i Sportu we Wrocławiu

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Małgorzata Dulnik
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Doktorant Akademii Wychowania Fizycznego i Sportu we Wrocławiu

Wrocław, 09.01.2023 r.

Oświadczenie o współautorstwie publikacji

Niniejszym oświadczam, że w pracy (*Jamro, D.; Zurek, G.; Lachowicz, M.; Lenart, D. Influence of Physical Fitness and Attention Level on Academic Achievements of Female and Male Military Academy Cadets in Poland. Healthcare (Basel) 2021, 9 (10), 1261)* mój udział polegał na:

[ ]	koncepcja pracy	[ ]	redagowanie publikacji
[X]	zaplanowanie badań wybór metodyki	[X]	zbieranie danych
[ ]	prowadzenie badań	[ ]	graficzne przedstawienie wyników
[ ]	analiza statystyczna	[ ]	zbieranie piśmiennictwa
[ ]	interpretacja wyników i opracowanie wniosków	[ ]	korekta pracy przed złożeniem do druku
[X]	konsultacja	[X]	inne: walidacja

Przyjmuję do wiadomości, że powyższa praca jako część rozprawy doktorskiej będzie podstawą do ubiegania się o nadanie stopnia doktora przez mgr. Dariusza Jamro.

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[X]	konsultacja	[X]	inne: walidacja, pozyskanie funduszy

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Podpis współautora

10.3. Certyfikat z konferencji

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