The Effect of a Dance-Like Martial Arts Program on Prisoners' Concentration Ability

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Abstract: *A cognitive prerequisite for education and (re)entry into the labor market is the ability to concentrate for a long period. Conducted with 39 participants, the present study examines the effect of a six-week dance-like martial arts program on prisoners' concentration ability in an open prison in Germany (n=15), and compares their concentration ability with a control group of prisoners (n=5), as well as a treatment (n=11) and control group (n=8) of university students. Concentration ability is assessed using the d2-R concentration and attention test before, after, and six weeks following the program. The program's participants showed significant improvements compared to the prisoners' control group, with levels eventually matching those of university students. The findings suggest that practicing voluntary sports with qualified coaches in an environment protected from observers enhance concentration ability and should, therefore, be implemented as an integral part of rehabilitation processes in prisons.*
Keywords: *Concentration Ability, Attention, d2-R test, Sport, Open Prison, Rehabilitation*

Introduction

The entering or re-entry of prisoners into the labor market is a declared goal of the penal system. A high standard of school education and integration into the labor market are key aspects to reduce recidivism (Hall & Killacky, 2008; McKean & Ransford, 2004). Employment represents a resilient factor that prevents people from committing (new) crimes (Berghuis, 2018). An important prerequisite for successful working processes is the individual's concentration ability, implying that prisoners need to be prepared to work quickly and accurately over an extended period. Several factors may complicate these efforts. First, most prisoners rarely present a successful school career, meaning there might be difficulties in motivating them for learning processes (Hetland et al., 2007). In addition, a negative attitude of prison officers toward education can also decrease the prisoners' motivation toward learning processes (Eide & Westrheim, 2023). Furthermore, problems inside the prison, such as adapting to subcultural rules, as well as outside the prison, such as relationship breakdown, make it difficult for prisoners to follow classes attentively (Patrie, 2017). However, bad cognitive performance can also reflect a lack of motivation (Schmidt-Atzert, 2004). Thus, there is a possibility that obligatory school offers might not be accepted by prisoners.

Voluntary offerings, such as sports programs, might be better suited to motivate prisoners and engage them in different types of learning processes. Voluntary sports activities (in prison), however, are usually not

associated with the promotion of cognitive processes. Instead, they counterbalance the monotonous prison routine and rehabilitation efforts (Lleixà & Ríos, 2015), and can provide prisoners with a 'moment of liberty' (Norman, 2017, p. 611). On the other hand, they can – especially through team sports – facilitate social integration processes (Müller & Schröder, 2023) or – especially through fitness programs – enhance health aspects (Meek & Lewis, 2012). However, evidence about how well or how much of the skills or knowledge acquired in prison can be applied to areas outside of prison is scarce (Müller & Schröder, 2023).

Sports science research outside the prison context has shown that academic achievement is significantly higher for students who participate in sports than for students who are not active in any sport (Ibis & Aktug, 2018). Furthermore, strenuous training seems to have a greater impact on academic performance than moderate training (Coe et al., 2006). Specifically, athletes who perform indoor sports were found to have a better concentration ability than athletes performing outdoor sports (Gür et al., 2018). Within the prison context, sports programs might also be a promising tool for facilitating prisoners' concentration ability that enhance cognitive processes. Therefore, it is worth investigating whether a specific sports program can enhance prisoners' concentration ability in a playful way. The present study extends the literature focusing on the rehabilitation of prisoners through sport and the effect of sport on concentration ability.

This study aims to examine the effects of dance-like martial arts training on prisoners' concentration ability. Martial arts are characterized by attacking and balancing movements without direct physical contact with the opponent. As a playful fight, it requires body control, which in turn can only be maintained through concentration. Martial arts can also easily be combined with dance elements. Dancing places fundamentally complex coordinative demands on participants (Predovan et al., 2019). Learning a dance movement sequence requires disciplined behavior, attentive cooperation, and adaptation to the music. Remembering the steps under time pressure appears to be more suitable than other sports programs to facilitate the development of concentration ability (Bastug, 2018). Thus, the combination of martial arts and dance has the potential to influence concentration ability positively.

More specifically, the present study examines the effects of a six-week dance-like martial arts program on prisoners' concentration ability and compares the outcomes with a control group of prisoners, as well as with a treatment and control group of university students. Concentration ability is assessed using the d2-R concentration and attention test (Brickenkamp et al., 2010). The intervention was carried out in an open prison in Germany. Open prisons provide a context for the targeted preparation of prisoners for the labor market while they are still in prison. Accordingly, the present study advances the following research questions: (1) How does a dance-like martial arts program affect prisoners' concentration ability? (2) How does the development of the concentration ability of those prisoners who participate in the dance-like martial arts program compare with the concentration ability of prisoners not participating in this sports program? And (3) how does the development of the concentration ability of those prisoners compare with the concentration ability of a treatment and control group of university students?

Literature Review

Concentration is the ability to work quickly and accurately under difficult conditions (Schmidt-Atzert et al., 2004). Given that concentration is often used as a synonym for attention, it is important to distinguish between the two concepts. Attention involves selective observation of relevant stimuli (e.g., in traffic), and is primarily concerned with assimilating information without being distracted in the process. Attention deficits are often associated with poor academic performance (Janssen et al., 2014). Concentration, on the other hand, encompasses the processing of received information and solving a specific task. According to this distinction, the d2-R concentration and attention test by Brickenkamp et al. (2010) or the letter cancellation task by Kumar and Telles (2009) are often used to measure these two abilities.

The systematic literature review by Janssen et al. (2014) and the meta-analysis by Alvarez-Bueno et al. (2017) show that a large number of studies exist that have investigated the effects of physical activity on attention in children. Although the d2-R concentration and attention test was also designed for adults, there are significantly fewer studies that have investigated the effects of sports and dance programs on adults' ability to concentrate. In their review, de Sousa et al. (2019) summarize existing evidence on the correlation between exercise and the concentration ability of individuals of different ages. For example, they show that aerobic exercise interventions generally lead to an improvement in attentional performance in young and old, but not

in young adults. Furthermore, not all forms of exercise are equally effective, and shorter interventions are less effective than longer ones. With regard to university students, who are the same age as the prisoner study group, Stroth et al. (2009) were unable to show any enhancements in concentration ability after six weeks of moderate endurance training with medical students. Regarding the effects of dance training on concentration ability, Bastug (2018) found positive effects after a 12-week dance program (including salsa, zumba, and modern dance) with physical education students. Overall, research on sports-based programs in the prison context remains rudimentary (Gallant et al., 2015) and needs to be advanced. In particular, there is no research available on the effects of sports-based programs on concentration in the prison context. The present study aims to address this research gap.

Method

Open Prisons in Germany and Prison of the Present Study

Regarding freedom-oriented prison regimes, the open prison system in Germany offers prerequisites for facilitating the transfer after release from prison and the start of a new life in liberty (Ministry of Justice North Rhine-Westphalia, 2023). Due to few precautionary measures, the open prison facility must take a special responsibility for the selection of prisoners, as only those who meet the requirements are selected (Ministry of Justice North Rhine-Westphalia, 2023), as well as those who do not abuse the open institution's possibilities to commit yet another crime. Although the open prison might seem like a light method of punishment, it is no reward for appropriate behavior but a treatment measure to provide the prisoners with as much normality in life as possible. However, the prisoners are not free to leave the premises on their own behalf, as they require individual permission associated with the sentence (Ministry of Justice North Rhine-Westphalia, 2023). Statistics show that by March 2021, 3,068 prisoners were registered in open prison facilities across North-Rhine Westphalia (Federal Statistical Office, 2021), offering them a chance to facilitate the crossover into freedom.

The present study was conducted in an open prison in North Rhine-Westphalia (NRW), Germany. The prison is a trial institution, which provides space for prisoners that still need to be under extraordinary surveillance, even though they are seen as suitable individuals for the open prison due to their crimes. The prison branch has 58 detention places for male prisoners, but it was not fully occupied at the time of the study due to the pandemic.

Sample

Overall, 46 participants (27 prisoners) took part in the study with a mean age of 25.63 (±5.23) years, of whom 39 (20 prisoners) completed all training and testing protocols. The average age of prisoners, 27.89 (±5.36), was approximately five years older than the average age of university students, 22.42 (±2.87). Of the 20 prisoners, 40% have a migration background, meaning either one of the parents or they themselves do not have German citizenship.

The program started with 20 prisoners in the treatment group, whose average age was 26.90 (±4.56) years, ranging from 23 to 41 years, and ended with 15 participants due to five dropouts (three due to attempt to escape - and therefore transfer to a closed prison, one due to transfer for safety reasons, and one due to transfer to another facility). For the prisoners in the treatment group, the average time of prison sentence already served at the beginning of the program was 9.25 (±11.36) months. The average total prison time the prisoners in the treatment group must serve amounts to 32.85 (±26.09) months. Considering the education of the prisoners in the treatment group, 15% have acquired a general university entrance qualification, 30% a general certificate of secondary education, 45% a certificate of secondary education, and 10% are still attending school.

The control group of the prisoners started with seven men, with an average age of 30.71 (±6.78) years, ranging from 25 to 43 years, and ended with five prisoners. The dropouts were due to medical reasons for one participant and the release from prison for the other participant. The participants in the control group did not perform sports regularly and only had the opportunity to use the gym room in the building for specific times a week. No further information considering the education or prison sentence was available. Moreover, conducting a control group in prison is a challenging task, as prisoners are firstly not willing to participate in research

studies without receiving a benefit (Herold et al., 2023). Second, prisoners cannot be randomized in a control group if they want to take part in the study due to ethical reasons.

Additionally, the intervention was repeated with a group of sports students with a similar study design (see section Study Design and Sports Program). Three reasons speak for this group as an additional comparison group. First, the sports students are also in the age of vocational training in the first and second semesters of their studies. Second, they share similar prior athletic experiences and only differ in their level of education (Czyrnick-Leber et al., 2022). Therefore, the effectiveness of the intervention would not be influenced by the athletic level. Third, the intervention could be conducted with the same instructor.

The treatment group of the university consisted of eleven male students, average age 22.00 (±3.29) years, ranging from 18 to 28. The sports students are engaged in various physical exercise activities multiple times a week and were, compared to the prisoners, generally more liberated in their activities outside the university.

Furthermore, the control group at the university amounted to eight students with an average age of 23.00 (±2.27) years, ranging from 19 to 26 years. The students in the control group also studied sports science at a German university in NRW and did not take part in the dance program like the control group in prison. The minimum level of education for all sports students was the general university entrance qualification. Table 1 gives an overview of the age and the duration of the prison sentence (prison sentence: only for the prison treatment group).

Table 1

Characteristics of Participants

	Prison		University	
	Treatment (n = 20)	Control (n = 7)	Treatment (n = 11)	Control (n = 8)
Age (years)	26.90 ±4.56	30.71 ±6.78	22.00 ±3.29	23.00 ±2.27
Prison Time (months)	32.85 ±26.09	n/a	n/a	n/a
Prison Time Served (months)	9.25 ±11.36	n/a	n/a	n/a

Study Design and Sports Program

The overall study design consisted of a sports program (dance-like martial arts training). Data were collected at three time points (pre-test, post-test, and six-week retention test). The duration of the intervention and the frequency in the university and prison context differed due to feasibility. The prisoners trained for six weeks, three times a week, for 60 minutes per session. The data for prisoners were collected from March to May 2021.

The program for university students lasted for eight weeks, with one training session per week lasting 90 minutes. At the three test points, the d2-R concentration test was conducted, and the procedure to conduct the test lasted approximately ten minutes. The d2-R will be described in detail in the section Testing Protocol. The data for university students were gathered between October and December 2021.

The dance-like martial arts training was designed and implemented by a female researcher and lecturer from university with a dance-specific background. Three female and one male student assisted and supported the program that included the concept of Fighting Monkey and Capoeira. Fighting Monkey is a training concept that challenges the athletes on a physical level but can also be seen as psychological and mental training. Other than that, it teaches the participants to take responsibility for themselves, try out new things, think innovatively, break down routines, and move intuitively. Capoeira is a Brazilian martial arts training that combines dance with acrobatics and music. It differs from other forms of martial arts training, like Judo, Karate, or Taekwondo, as the athletes dodge their rivals rather than use blows and kicks, and is, therefore, considered a non-contact sport. Hence, fluent movements not only enable the enhancement of physical but also mental fitness, and the spontaneity that plays a significant role in this sport requires the brain to act and react the right way, leading to the requirement of concentration.

Consequently, the training concept that is the composition of Fighting Monkey and Capoeira seems to be suitable for the work with prisoners, as these are two types of sports that they either do not know or can only connect to martial arts training, which many participants are fond of (Czyrnick-Leber et al., 2022). The concentration ability is challenged by the fact that the participants not only have to remember the steps when learning the choreography but also have to perform them correctly. To remember the steps more easily, the participants work with 'metaphorical anchor points', which are announced by the trainer during the choreography. In addition to that, music is a relevant factor in the training concept, as it goes hand in hand with dance and, in the case of this study, dance-like martial arts training.

Testing Protocol

For the measurement of concentration, the d2-R test (Brickenkamp et al., 2010), a paper-pencil method, was performed. The d2-R test is a globally established method for measuring attention and concentration (Yato et al., 2019). The high reliability, criterion-related validity, construct validity, and predictive validity of the test have been confirmed by previous research (Yato et al., 2019). Due to its short duration of less than five minutes, it is also widely used in practice (e.g., Altermann & Gröpel, 2023; Budde et al., 2008; Gallotta et al., 2015; Stroth et al., 2009). The test consists of a total of 798 items. The test contains different letter items "d" and "p" with between one and four dashes (see Figures 1 and 2). The goal is to mark all target objects ("d" with two dashes) as fast as possible.

Figure 1

Exemplary Section of the d2-R Test

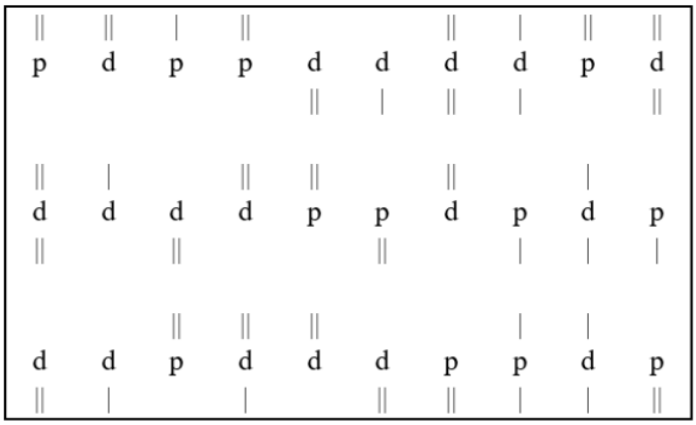
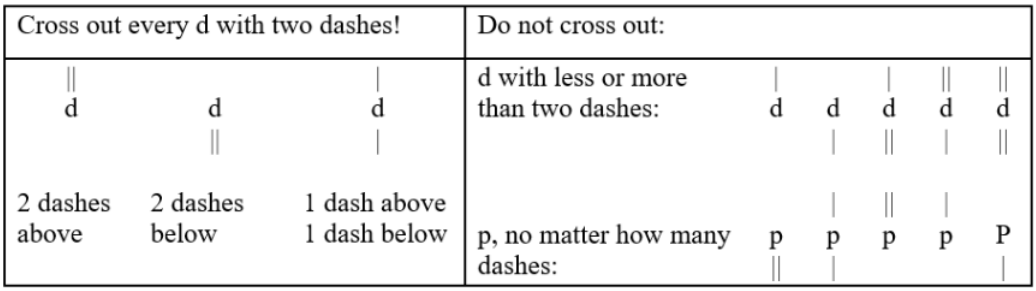


Figure 2

d2-R Test Instruction on Target Object



which is calculated by the PTO minus the total number of errors, percentage of errors (E%), calculated by the total number of errors divided by the PTO multiplied by 100, number of omission errors (EO), all missed target objects and number of commission errors (EC), all wrongfully crossed-out objects. However, in the present study a sixth dependent variable (i.e., total number of errors, ET) consisting of the addition of EO and EC was also calculated to offer a deeper insight into the participant's test performance. Table 2 presents the mean values of the dependent variables for all participants over the three measurement points.

Table 2

Overview of Variables (n=125)

Name	Description		Mean	SD
Outcomes				
PTO	Number of processed target objects (work speed)		196.80	44.44
CP	Concentration performance = PTO- number of omission and commission errors		172.07	47.86
E%	Percentage of errors = (Number of errors/PTO)*100		12.60	13.72
EO	Number of omission errors (i.e., number of target objects not crossed out)		20.36	23.09
EC	Number of commission errors (i.e., number of non-target objects crossed out)		4.37	15.72
ET	Number of total errors (= EO+EC)		24.73	28.45
Factor			%	
Time	Measurement point	1=pre	36.8	
		2=post	32.0	
		3=after 6 weeks	31.2	
Context	Context of test completion	0=university	44.0	
		1=prison	56.0	
Group	Assigned group	0=control group [CG]	33.6	
		1=treatment group [TG]	66.4	

Statistical Analysis

The empirical analyses were carried out in SPSS 28. Due to the small sample size in combination with dropouts, mere pre-post comparisons are not adequate. Therefore, the data were organized as a vertical panel, leading to 125 observations. First, the variables' descriptive statistics (mean and SD values) were obtained. Then, multifactorial ANOVAs were calculated to answer the research question. The data analysis was carried out according to previous studies measuring and examining the effects of sports on concentration ability (Gallotta et al., 2015; Kulinna et al., 2018). Overall, six dependent variables from the d2-R testing were of interest (Table 2). For each outcome variable, a 2 × 2 × 3 multifactorial ANOVA was performed with three factors, measurement point (pre-test vs. post-test vs. six weeks after) representing the time factor, the context of test completion (prison vs. university) representing the factor of context and assigned group (control vs. treatment group) representing the factor group. Bonferroni's corrected post hoc tests were conducted to further analyze the significance of the measurement points. Additionally, to statistical significance, effect sizes were reported using partial eta-square ($\eta 2$) for tests that reached statistical significance of an alpha level of 0.05. According to Cohen (1988), $\eta 2 = 0.01$ represents a small, $\eta 2 = 0.06$ a medium, and $\eta 2 = 0.14$ a large effect.

Results

Table 3 shows the *p*-values for the ANOVAs and their respective main and interaction effects. For the interaction effects with the factors time×context×group, the multifactorial ANOVAs did not reach the alpha level of $p < .05$ for any dependent variables, meaning no significant interaction effects were found.

Table 3

Results of the Multifactorial ANOVAs (displayed are the p-values, n=125)

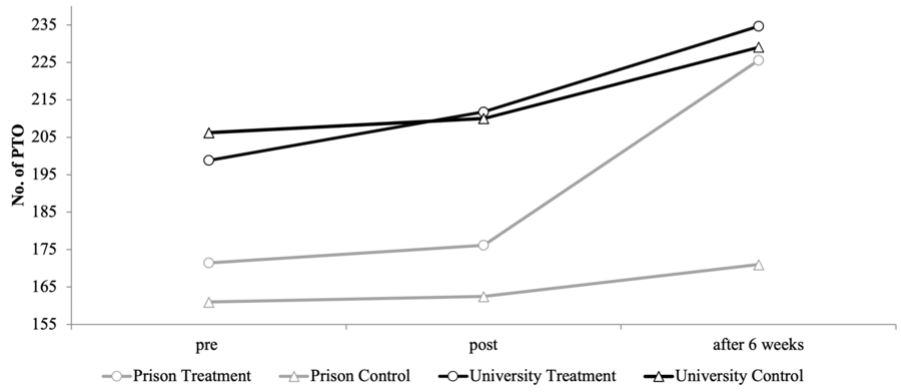
	PTO	CP	E%	EO	EC	ET
Time	.002** (.10)	<.001*** (.20)	<.001*** (.12)	<.001*** (.13)	.460	.009** (.08)
Context	<.001*** (.18)	<.001*** (.24)	.028* (.04)	.093	.726	.257
Group	.079	.010* (.06)	.110	.311	.565	.254
Time × Context	.908	.545	.124	.733	.369	.436
Time × Group	.263	.396	.336	.173	.550	.473
Context × Group	.079	.982	.056	.054	.117	.015* (.05)
Time × Context × Group	.565	.937	.489	.915	.392	.596

Note. *p<0.05, **p<0.01, ***p<0.001. Effect sizes (partial eta-squared) for significant values are presented in brackets.

The descriptive values, however, speak in favor of the intervention. Especially for the treatment group in the prison context, the concentration seems to have improved from time point one to three (see Figure 3). The PTO values increased by about 31.5% to 225.53 PTO (from 171.45) for the prison treatment group. Meanwhile, the PTO values of the prison control group increased only about 6.2% (from 161.00 to 171.00). The university groups likewise did not show such an increase in the PTO values: the treatment group only increased about 18.0% (from 198.82 to 234.64) and the control group about 11.0% (from 206.25 to 229.00).

Figure 3

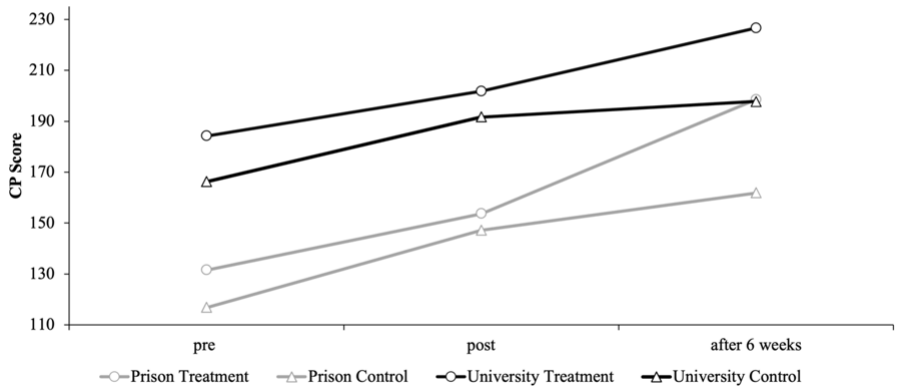
Number of Processed Target Objects of the Groups over Time



Similar changes can be reported for the concentration performance (CP) from time points one to three. The prison treatment group had the highest increase here as well, improving the CP score by about 50.9% to 198.47 (from 131.55). The increase in the prison control group was only about 38.5% (from 116.86 to 161.8). For the two groups in the university context, the increase amounts only to 23.0% (from 184.18 to 226.55) for the university treatment group and 18.9% (from 166.25 to 197.75) for the university control group. Figure 4 shows the CP values and the change over time.

Figure 4

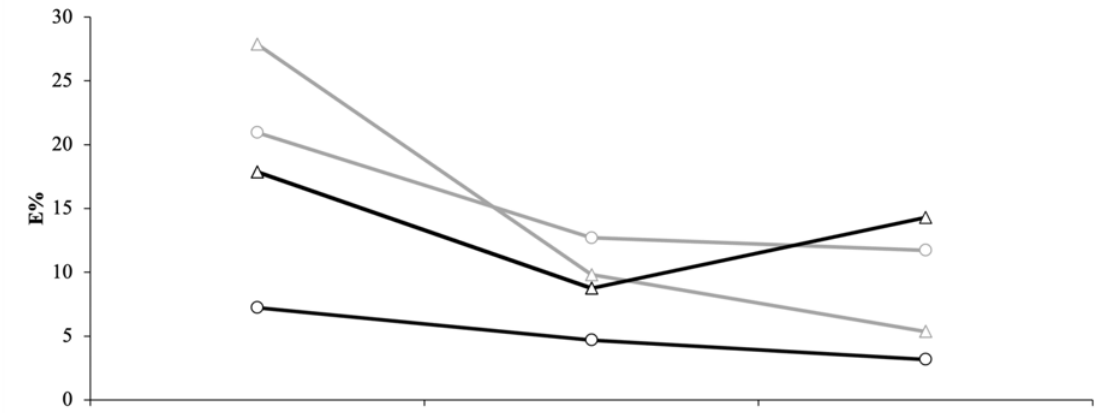
Concentration Performance of the Groups over Time



For the percentage of errors (E%), the changes are rather in favor of the control group in the prison context, which had the highest decrease from 27.9% errors in the pre-test to 5.4% in the retention test, whereas the prison treatment group only shows a decline from an E% of 20.9% to 11.7%. The university treatment group improved their E% from 7.2% to 3.2%, and the university control group from 17.9% to 14.3% from time points one to three. However, the control group in the prison context had the highest E% and, therefore, the most room for improvement. Moreover, the control group in the university context had their lowest E% at time point two with 8.7% and aggravated after that to 14.3%. Figure 5 shows the E% values and the change over time.

Figure 5

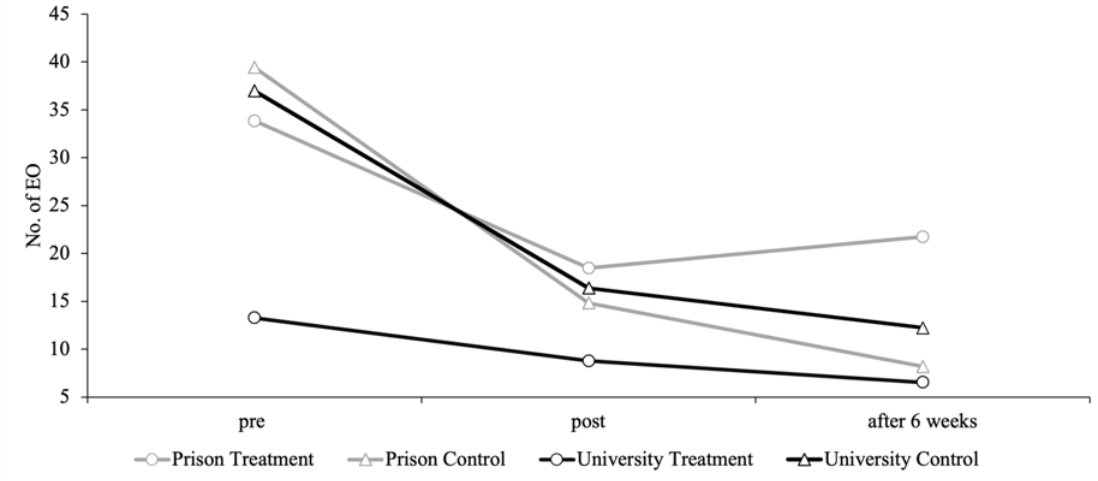
Percentage of Errors of the Groups over Time



The number of omission errors (EO) decreased the most for the two control groups. In the prison control group, the number of EO decreased by 79.2% to 8.2 omission errors (from 39.43), and for the university control group by 66.9% to 12.25 omission errors (from 37.00). The treatment group in prison meanwhile only decreased by 35.8% (from 33.85 to 21.73), accounting for the smallest change, and the university treatment group by 50.6% (from 13.27 to 6.55). Figure 6 shows the EO values and the change over time.

Figure 6

Number of Omission Errors of the Groups over Time

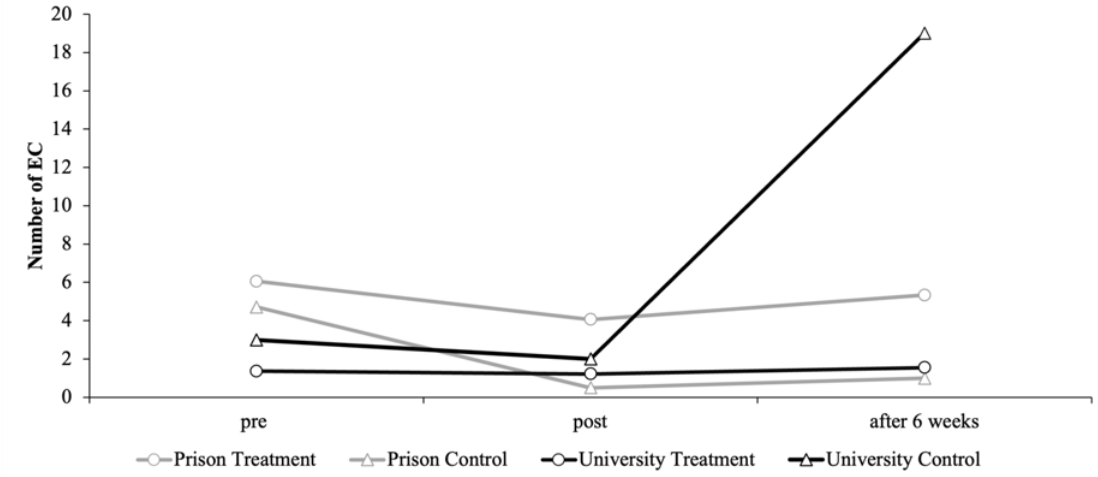


The changes for the commission errors (EC) showed a very large increase for the university control group by over 500%, from an average of three commission errors to 19 commission errors. In contrast to that, the other groups' changes were more moderate. The university treatment group displayed a slight increase in errors by 14%, from 1.36 to 1.55 errors. In the prison context, both groups managed to improve their errors.

The prison treatment group reduced their errors from time point one (6.05) to time point three (5.33) by 11.9%, and the prison control group lowered their commission errors down to 1.0 errors (from 4.71 errors), resulting in a decrease of 78.8%. Figure 7 shows the EC values and the change over time.

Figure 7

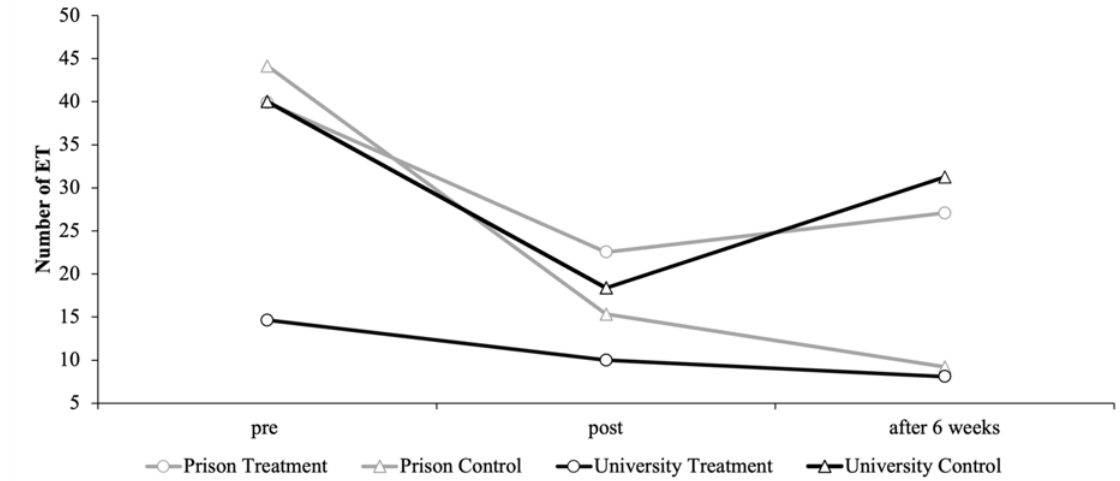
Number of Commission Errors of the Groups over Time



For total errors (ET), all groups showed a decrease from time point one to time point three. The largest decrease in total errors (ET) can be found in the prison control group, with a change of 79.2% to 9.2 ET (from 44.14), followed by the university treatment group lowering their errors to 8.09 (from 14.64) by 44.7% and the prison control group with a change of 32.2% to 27.07 (from 39.90). The smallest change is shown by the university control group from 40.00 to 31.25 (ET), resulting in a change of 21.9%. Figure 8 shows the ET values and the change over time.

Figure 8

Number of Total Errors of the Groups over Time



The main effect time shows for the PTO values significant differences between at least two of the time points with a medium effect size, $F(2, 113) = 6.34$, $p = .002$, partial $\eta 2 = .10$. The post hoc test revealed that between time point one and three and between time point two and three the PTO values significantly differed ($M = 182.46$, $SD = 41.04$ vs. $M = 221.82$, $SD = 42.49$, $p < .001$ and $M = 188.90$, $SD = 40.57$ vs. $M = 221.82$, $SD = 42.49$, $p < .001$), showing a significant increase over time for the PTO values.

For the concentration performance (CP), the multifactorial ANOVA also reached the alpha level of .05, indicating a significant main effect with a large effect size, $F(2, 113) = 13.84$, $p < .001$, partial $\eta 2 = .20$. In the post hoc test significant differences between time point one and two ($M = 147.93$, $SD = 41.12$ vs. $M = 171.10$, $SD = 41.15$, $p = .015$), time point one and three ($M = 147.93$, $SD = 41.12$ vs. $M = 201.54$, $SD = 46.22$, $p < .001$) and time point two and three ($M = 171.10$, $SD = 41.15$ vs. $M = 201.54$, $SD = 46.22$, $p < .001$) can be reported for the post hoc analysis, resulting in a better concentration performance (CP) in the retention test.

The main effect time of the E% also reached statistical significance and a medium effect size, $F(2, 113) = 7.38$, $p < .001$, partial $\eta 2 = .12$. The post hoc analysis for the percentage of errors (E%) revealed significant differences between time point one and time point two ($M = 18.18$, $SD = 17.14$ vs. $M = 9.67$, $SD = 7.55$, $p = .006$) and between time point one and three ($M = 18.18$, $SD = 17.14$ vs. $M = 9.02$, $SD = 12.14$, $p = .003$).

Similar results can be reported for the omission errors (EO), $F(2, 113) = 8.30$, $p < .001$, partial $\eta 2 = .13$. Post hoc analysis showed significant differences between time point one and two ($M = 30.33$, $SD = 31.00$ vs. $M = 15.33$, $SD = 13.73$, $p < .01$) and time point one and three ($M = 30.33$, $SD = 31.00$ vs. $M = 13.77$, $SD = 14.74$, $p < .01$), meaning that over the time the omission errors (EO) decreased.

Table 4

Development of the Dependent Variables for Main Effect Time

	Pre	Post	After 6 weeks	p	η_p^2
PTO	182.46 ±41.04	188.90 ±40.57	221.82 ±42.49	.002	.10
CP	147.93 ±41.12	171.10 ±41.15	201.54 ±46.22	<.001	.20
E%	18.18 ±17.14	9.67 ±7.55	9.02 ±12.14	<.001	.12
EO	30.33 ±31.00	15.33 ±13.73	13.77 ±14.74	<.001	.13
EC	4.2 ±15.14	2.47 ±5.28	6.51 ±22.31	.460	n/a
ET	34.52 ±35.55	17.80 ±14.68	20.28 ±27.12	.009	.08

The multifactorial ANOVA for the total errors (ET) also reached statistical significance and a medium effect size, $F(2, 113) = 4.95$, $p = .009$, partial $\eta 2 = .08$. The post hoc analyses for the main effect time for the total errors (ET) only revealed a significant difference between time point one and two ($M = 34.52$, $SD = 35.55$ vs. $M = 17.80$, $SD = 14.68$, $p < .05$), while the other time points did not significantly differ ($p > .05$). Only for the commission errors (EC), no significant differences can be stated for the main effect time of the multifactorial ANOVA, $F(2, 113) = 0.78$, $p = .46$.

For the main effect context, only three dependent variables reached statistical significance PTO, $F(1, 113) = 25.15$, $p < .001$, partial $\eta 2 = .18$, CP, $F(1, 113) = 35.24$, $p < .001$, partial $\eta 2 = .24$, and E%, $F(1, 113) = 4.94$, $p = .028$, partial $\eta 2 = .04$. Since the factor context consists of two contexts, no post hoc analysis is necessary. The number of PTO was significantly higher for the university students compared to the prisoners ($M = 215.20$, $SD = 37.21$ vs. 182.34, $SD = 44.55$, $p < .001$). The same observation can be reported for the concentration performance (CP) ($M = 195.98$, $SD = 44.59$ vs. $M = 153.29$, $SD = 43.87$, $p < .001$), where the university students scored significantly higher and the percentage of errors (E%), where the university students made significantly fewer errors ($M = 8.80$, $SD = 11.52$ vs. $M = 15.59$, $SD = 14.61$, $p < .028$).

Exclusively for the concentration performance score (CP), the main effect group showed a significant difference, $F(1, 113) = 6.93$, $p = .01$, partial $\eta 2 = .06$), reporting a higher concentration performance for the treatment group ($M = 175.35$, $SD = 47.07$ vs. $M = 165.60$, $SD = 49.31$). The two interaction effects, time×context, and time×group, did not reach statistical significance ($p > .05$). Therefore, no interaction effects can be reported for any of the variables concerning these factor combinations.

For the interaction context×group, a statistically significant interaction was found for the number of total errors (ET), $F(1, 113) = 6.11$, $p = .015$, partial $\eta 2 = .05$). Post hoc analyses revealed that, in the university context, the treatment group had fewer errors than the control group ($M = 10.97$, $SD = 11.04$ vs. $M = 29.88$, $SD = 34.98$, $p = .011$). Moreover, the university treatment group had significantly fewer total errors (ET) than the prison treatment group ($M = 10.97$, $SD = 11.04$ vs. $M = 30.52$, $SD = 29.45$, $p = .003$).

Discussion

The primary aim of this study was to investigate the effects of dance-like martial arts training on prisoners' concentration ability. This is the first study trying to enhance attention and concentration in a prison context through a sports program. Regarding the first research question (impact on prisoners' concentration ability), we found that the dance-like martial arts program substantially improves prisoners' attention and concentration, as measured by concentration performance (CP), processed target objects (PTO), and the percentage of errors (E%).

Regarding the second research question (comparison with non-active prisoners), we found a stronger increase in CP and PTO for the treatment group compared to the control group. Also, the final scores for the descriptive values for the PTO and CP values are much higher in the prison treatment group compared to the prison control group. For the main effect (group), only for the CP a significant difference was found in favor of the treatment group. This finding indicates an improvement in concentration performance through the intervention and is in line with the study by Bastug (2018). Contrary to the present study, Stroth et al. (2009) found no improvements in the treatment group's CP and argued that the concentration test requires too little effort, which is not the case in the present study. In the prison context, the treatment group already performed better in the CP and PTO than the control group at the pre-test. These differences might be due to the age gap between the treatment and control group, as prisoners in the treatment group were on average four years younger (Table 2), and research shows a decline in cognitive functions with increasing age (Deary et al., 2009). However, the prisoners were still in the same age ranges according to the d2-R (Brickenkamp et al., 2010). Moreover, the differences in the pre-test were not statistically significant.

Last, to answer the third research question (comparison with treatment and control group of university students) we found a higher benefit for the prison treatment group in relative terms, as signalled by the percentage change regarding their CP and the PTOs. Although these findings did not reach statistical significance for any of the interaction effects (except the interaction context×group on total errors), it is remarkable that the prisoners could improve several variables of the d2-R test to a similar level to that of university students after a six-week intervention phase, despite having an inferior baseline level. The more marginal improvements for the students could be explained by the compensation theory (Karbach & Unger, 2014), meaning people with less room for improvement benefit less from cognitive training. On the other hand, this could be due to the higher overall physical activity level of the students who, hence, did not benefit at the same level as prisoners did (Shephard, 1997). Moreover, for the main effect context, the multifactorial ANOVA revealed significantly better values for the PTOs, the CP, and the E% for the university context. These results are as expected since the university environment is more facilitating for concentration than the prison environment.

Considering the COVID-19 regulations, the intervention in the prison was obliged to take place outside, while the students were able to train inside. This might lead to two issues. First, research has shown that concentration performance is better for indoor activities (Gür et al., 2018). However, this makes the improvement of the prisoners even more remarkable. Second, the prisoners were under constant observation by other prisoners who did not take part in the intervention, which led to a disturbance of the training group and, therefore, decreased attention towards the instructors and the training (Herold et al., 2023). Additionally, earlier studies have reported low attention and concentration levels for prisoners during interventions and test administrations (Hosser & Greve, 1999).

For the main effect time, all dependent variables, except the commission errors (EC), significantly improved. The lack of improvement of the ECs can result from the already low baseline values. Therefore, almost no room was left to improve this variable. To further deconstruct the change over time, the interaction effect of time and group was examined, which showed no significant differences, leading to the conclusion that all groups, even the control groups, had changes in the dependent variables of the d2-R. This is explained by the known retest effects of the d2-R test (Schmidt-Atzert et al., 2021).

As outlined in the results section, the improvements in the CP and PTO values in the prison treatment group are seen between the post-test and the retention test. Normally, one would expect the improvements to appear in the post-test and a slight decline in the retention test. The reason for this might be due to the announcement of the second COVID-19 lockdown one hour before the planned post-test data acquisition, as the mood and overall situation were tense, and the prisoners were afflicted with negative emotions leading to revolts, with four prisoners trying to escape the prison. This might have led to a decrease in performance

in the second measurement point of the d2-R test as these data were gathered a few days later. Because negative emotions can lead to a decrease in concentration (Vast et al., 2010), this event might explain the lack of improvement in the concentration variables from the pre-test to the post-test.

Limitations

The present study has several limitations, which need to be considered when interpreting and reviewing the results. First, the study took place in an open prison in Germany. As mentioned, a prisoner in this type of prison can leave the facilities for work and other activities experiencing higher daily freedom compared to prisoners in closed prisons. Future interventions should try to replicate these findings in other settings. Another limitation is that other possible determinants of concentration ability, such as education before imprisonment, education during imprisonment, or learning bias were not assessed in the study and can, therefore, not be included as controls in the analysis. Additionally, the sample in the present study is rather small. A larger sample size would lead to better power and could give more insights into the effectiveness of dance-like martial arts training for concentration performance. Moreover, with 40% of the prisoners having a migration background and rather low levels of education, some communication problems with the instructors and understanding problems during the test administrations were reported.

Implications for Future Research and Practical Implications

Notwithstanding the limitations, the present study provides new insights into the positive aspects of dance-like martial arts training with prisoners, from which future researchers and practitioners in a prison context can benefit. Researchers and practitioners should conduct future interventions in a more private environment (e.g., gym or recreation room), to which only the participants of the intervention have access so that they do not have a feeling of judgment and observation from others. As mentioned before, the aspects of indoor activities and exclusion of non-participants could lead to better concentration but also higher adherence and a higher overall number of participants. Moreover, in the future, an extension of the research to closed prisons and with female prisoners is needed to see if similar effects can be found there as well. Additionally, interventions investigating the effects of other training modes (endurance or strength training) on concentration in prison are necessary. Future training programs and studies should pay attention to the qualification of the instructors and the concept of the training program because well-qualified instructors, as well as the design of the program, are a requirement for the success of sports programs (Telford et al., 2012).

On the practical side, it would be useful for prisons to offer a variety of voluntary sports programs. In this way, prisoners would be able to choose a sport of their personal preference and could therefore benefit from the positive effects of a sports program (e.g., improved concentration ability), which could transfer to the reentry process in the labor market. Additionally, cooperation between prison sport programs and sport programs outside of prison could ensure a smooth transition after release to sustain the positive improvements from sport beyond the time of imprisonment. The dance-like martial arts program seems to be appropriate for the prison and university context. However, it should be compared to other sports programs, which might also provide support for cognitive improvements playfully, and thus, academic performance.

Conclusion

The present study aims to reduce the lack of research on the concentration ability of prisoners and contributes to the literature in multiple ways. First, it gives additional insight into the effects of dance programs on the concentration ability of students and, more importantly, prisoners. Second, the study contributes to the provision of a specific sports program (combining martial arts and dance) adapted to the prison context. Third, the study shows that a voluntary sports program seems suitable to support academic performance in a targeted manner and should therefore be implemented as an integral part of rehabilitation processes in prisons. Moreover, prisoners had a strong feeling of pride due to their improvements in concentration ability. This could translate into a higher motivation for adherence and participation in other voluntary programs in prison and facilitate further education processes.

All in all, the study has shown that dance-like martial arts training improves the attention and concentration of university students and prisoners. Despite the much tougher circumstances prisoners are exposed to in day-to-day life, and also with the COVID-19 regulations, it is remarkable that prisoners were able to improve their concentration ability to a similar level to that of university students.

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