

## Enhanced attention and memory in slackline practitioners: a descriptive study Aumento de la atención y la memoria en practicantes de slackline: un estudio descriptivo

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**Abstract.** Introduction: It has been shown that the practice of slackline, a sports discipline that consists of balancing on a rope anchored between two fixed points, not only can improve motor aspects such as body balance and postural control, but also cognitive aspects such as spatial orientation. Here we wonder whether the practice of slackline is related to other cognitive functions such as attention and/or memory. Materials and methods: Slackline practitioners were invited to take the Toulouse-Pieron test to assess attention and the Benton test to assess visual memory. The same tests were applied to a control group composed of people of the same age and with the same educational level. Results: 14 slackline practitioners, mean age  $23.7 \pm 4.1$  years, and 14 controls, mean age  $23.5 \pm 3.5$  years, participated in the study. When comparing the groups, we observed differences of 20% in the memory score ( $p < 0.001$ ) and 30 points in the attention test ( $p = 0.031$ ) in favor of the slackline group. In addition, a high direct correlation was observed between years of slackline practice and attention ( $r = 0.710$ ), and a moderate direct correlation between years of slackline practice and visuospatial memory ( $r = 0.332$ ). Conclusion: These findings allow us to suggest practice of slackline is related to enhanced attention and memory and may represent a prophylactic alternative to generate functional reserves or to treat cognitive disorders such as ADHD.

**Keywords:** cognitive functions, executive functions, body balance and physical activity.

**Resumen.** Introducción: ha sido demostrado que la práctica de slackline, disciplina deportiva que consiste en balancearse sobre una cinta anclada entre dos puntos fijos, no sólo puede mejorar aspectos motores tales como el balance y el control postural, sino que también aspectos cognitivos tales como la orientación espacial. Aquí nos preguntamos si la práctica del slackline está relacionada a otras funciones cognitivas, tales como la atención y/o la memoria. Materiales y métodos: practicantes de slackline fueron invitados a realizar la prueba de Toulouse-Pieron para evaluar su atención y la prueba de Benton para evaluar su memoria visual. Las mismas pruebas fueron aplicados a un grupo control compuesto por personas de la misma edad y nivel educacional. Resultados: 14 practicantes de slackline, edad promedio  $23,7 \pm 4,1$  años, y 14 controles, edad promedio  $23,5 \pm 3,5$  años, participaron en el estudio. Al comparar los grupos, observamos diferencias de un 20% en el puntaje de memoria ( $p < 0,001$ ) y 30 puntos en la prueba de atención ( $p = 0,031$ ) a favor del grupo slackline. Además, se observó una correlación directa y alta entre los años de práctica de slackline y la atención ( $r = 0,710$ ) y una correlación directa y moderada entre los años de práctica de slackline y la memoria visuoespacial ( $r = 0,332$ ). Conclusión: estos hallazgos nos permiten sugerir que la práctica de slackline estaría relacionada a una atención y memoria exacerbada y podría representar una alternativa profiláctica para generar reservas funcionales o tartar desórdenes cognitivos, tales como TDAH.

**Palabras clave:** funciones cognitivas, funciones ejecutivas, balance corporal y actividad física.

Fecha recepción: 21-07-22. Fecha de aceptación: 04-01-23

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### Introduction

The ability to stand, that is, bipedal corporal balance, and cognitive abilities vary throughout our lives (Suzuki et al., 2018), associating aging with a decline or deficits in cognitive functions, as well as in the loss of postural control, manifested in an increased risk of falls (Hwang & Ahn 2021). From a therapeutic point of view, this fact has motivated investigators on one hand to look at interventions that help to stop the progress of the associated deficits, such as exercising to reduce the progress of these functional declines (Huang et al., 2014; Whiteman et al., 2014, Whiteman et al., 2016), and, on the other hand, from a prophylactic perspective, that we should look at interventions that promote activities which generate active behaviors in healthy people that could enhance their physical and mental abilities.

Curiously, recent evidence has shown that body balance training, specifically slackline, a sport where balance must be maintained on a tape anchored between two points, in addition to improving balance and postural control (Donath et al., 2017), has been able to improve a

cognitive function; spatial orientation (Dordevic et al., 2017, Hötting et al., 2021).

Slacklining consists of maintaining balance on a mobile flat rope tensioned between two anchor points, which has been considered an attractive and demanding alternative to traditional balance training (Reyes-Ferrada et al., 2021; Donath et al., 2017; Paoletti and Mahadevan, 2012). It is worth mentioning that, in general, the greatest physical demands in terms of body balance are performed on stable surfaces, as is the case with ballet, ice skating or even the barre in Olympic gymnastics (Hüfner et al., 2011), but in the case of slacklining, one walks and perform pirouettes similar in execution difficulty to the mentioned disciplines on a smaller and unstable surface, a flat rope 4 or 6 cm wide, which multiaxially challenges the balance in a dynamic and unstable way (Dordevic et al., 2017).

According to the international slackline association (ISA), within the slackline there are different disciplines, one of the best known is the "trickline", which consists of placing a pre-stressed rope to be able to walk and jump doing tricks on it. In addition, depending on how and where the rope is located, we find the "longline", whose

characteristic is to walk on a rope of more than 40 meters long. Another modality is the “highline”, where the rope is located above 20 meters high. There is also a modality in which the rope is poorly tensed, remaining in the shape of a u, where pirouettes and postures like yoga are performed, called “rodeoline”, (<https://www.slacklineinternational.org/what-is-slacklining/>).

Neuromuscular adaptations in different levels have demonstrated to be responsible of postural improvements after slackline, such as the reduction of the H reflex (Keller et al., 2012), as well as central structural changes, inducing greater efficiency in the striated circuits, motor control (Magon et al., 2016), and volumetric increase in the hippocampus (Hüfner et al., 2011), key structures for both motor and cognitive functioning.

Taken together, all the evidence supporting that slackline practice has been able to generate changes in these essential circuits for executives’ functions, added to the evidence of how physical activity can generate neuroprotectors that help enhance cognitive functions (Huang et al., 2014), make us wonder whether the systematic practice of slackline could enhance other executive functions as memory and attention. Thus, the purpose of this study was to determine the type of relationship between the years of slackline practice and two executive functions: attention and memory, to look at interventions that help to generate a cognitive functional reserve through physical activity.

## Materials and methods

This was a cross-sectional descriptive study, with a correlational scope of two executives’ functions, attention and memory in healthy people. More precisely, we compared a group of people who practice slackline with match-to sample people who do not practice slackline, but with similar age and educational level. On one single session participants from both groups were invited to the laboratory for data collection. First, the informed consent was signed, and then attention and memory tests were applied by P.P, P.B and R.G to all participants.

### Participants

Slackline practitioners with at least 3 years of training experience from slackline clubs from Valparaiso, who train at least three-time one-hour per week (or the equivalence volume training as WHO recommended) were invited to participate in this study, and they were matched with people without slackline experience, but with same age and educational level, excluding people under 18 years old, and those who present some neurological diagnosis, dysfunction, or cognitive deficit.

### Procedure

Once the informed consent was known and signed, the groups were constituted and all the volunteers were invit-

ed to a single session, where they were given the specific tests of attention through the Toulouse-Pieron test and memory through the Benton test, respecting the protocols of each of test, granting a break of 15 minutes between tests.

### Executive function tests

The Toulouse-Pieron test was applied to evaluate attention. This test assesses the aptitude or ability to focus the attention on tasks whose main characteristic is monotony. The test gives a score which is categorized into 5 levels: High, over average, average, under average and low. For more details on its application and classification, consult the test application guidelines (Toulouse & Pieron, 1986; Maureira et al., 2014).

The Benton visual retention test was applied to evaluate memory. This is an instrument designed to evaluate visual perception, visual memory, and visuo-constructive ability. The test comprises three alternative forms: C, D and E, being form D the one used in this study. Briefly, this test consists of the replication of images that are presented in 10 separate slides, for 10 seconds each, with a 15-second pause to then allow replication for another 10 seconds. This procedure is repeated until the 10 sheets are finished. Then a score is given, which corresponds to the percentage of correctly replicated slides (Benton AL, 1981, Maureira et al., 2014).

### Data analysis

The data was stored and tabulated in a Microsoft Excel 2013 spreadsheet, identifying the participants with alphanumeric codes, and then analyzed using descriptive and inferential statistics (mean, standard deviation, minimum and maximum values), as well as frequency tables. A second stage of statistical analysis was carried out with the XLSTAT 2018 program, a complement for Excel 2013. The Shapiro-Wilk test was used to verify the normal distribution of each of the study variables and thus compare the data by applying the T test of Student.

For data that did not present a normal distribution, the U-Mann Whitney was used. A p value less than 0.05 was considered a statistically significant value. Finally, the Pearson test was used to determine a correlation between the years of practice of the slackline group with its results obtained in the Toulouse-Pieron tests and the Benton test.

## Results

### Participants

An amount of 28 people participated in this study, 14 slackline practitioners with an average age of  $23.14 \pm 3.63$  years and 14 residents of Valparaíso, who conformed the control group, with an average age of  $23.07 \pm 1.85$  years (Table 1).

Table 1.  
Participant’s characterization

Groups	n	Age (years $\pm$ SD)	M (%)	W (%)
Slackline	14	23.1 $\pm$ 3.6	85.7	14.3
Control	14	23.1 $\pm$ 1.9	42.9	57.1

n: number of participants; SD: standard deviation; M: men; W: women

Regarding the slackline disciplines of the participants in this study, all of them reported having started practicing trickline, in a competitive level. At the time of the study, 10 practitioners continue to dedicate themselves exclusively to trickline practice, three of them practice trickline and contact, and only one practitioner is dedicated to longline and highline practice.

**Attention**

The categorization according to scores obtained individually yields the following results: within the group of slackline practitioners, 71.4% (10/14) were classified as over average category and high category, with the remaining 28.6% classified as under average category and low category, and no participant were classified in normal category.

While 78.6% (11/14) of people in the control group were classified as under average category and a low category, 3 people, corresponding to 21.4% of the control group, were classified as an over average category and a high category. It should be noted that there were no people classified in the normal category in any group, showing an opposite pattern of score between the groups (table 2).

Table 2. Results obtained in the attention test

Category	% Control (n)	% Slackline (n)
Low	14.3 (2)	14.3 (2)
Under Average	64.3 (9)	14.3 (2)
Average	0	0
Over Average	14.3 (2)	57.1 (8)
High	7.1 (1)	14.3 (2)

% Control: percentage of the control group sample; % Slackline: percentage of the slackline group sample; n: number of participants in the corresponding group.

**Memory**

All the slackline practitioners obtained a score equal to or greater than 70%, where 43% (6/14) reached 80 points, 36% (5/14) reached 90 points and one slackline practitioner obtained the maximum score in this test (see table 3). Regarding the control group, 29% of the participants (4/14) achieved between 40 and 50 points (out of a total of 100), while 63% (9/14) achieved between 60 and 90 points. It is important to note that no participant in the control group reached 100 points on the visual memory test.

Table 3. Results obtained in the visual memory test

Score	% Control (n)	% Slackline (n)
40	7.1 (1)	0
50	21.4 (3)	0
60	14.3 (2)	0
70	14.3 (2)	14.3 (2)
80	28.6 (4)	42.9 (6)
90	7.1 (1)	35.7 (5)
100	0	7.1 (2)

% Control: percentage of the control group sample; % Slackline: percentage of the slackline group sample; n: number of participants in the corresponding group.

**Inter groups Comparison**

When comparing the results of the Toulouse-Pieron

test between groups, a difference of 30 points was observed in favor of the group that practices slackline ( $p < 0.031$ ). While comparing the groups in the memory test, the slackline group obtained a difference of 20% over the control group ( $p < 0.001$ ). The details of these results are shown in Table 4 and Figure 1.

Table 4. Summary of the results of the visual memory and attention tests of both groups

	Benton Test			Toulouse-Pieron Test		
	Control	Slackline	Δ Groups	Control	Slackline	Δ Groups
Average	64.3	83.6	20%	186.9	217.5	30.6
SD	16.5	8.4	8%	33.5	37.3	3.8
Max	90	100	10%	254	274	20
Min	40	70	30%	125	155	30

Δ Groups: difference between groups; SD: standard deviation; Max: maximum value observed; Min: minimum value observed.

a) Toulouse-Pieron test b) Benton test

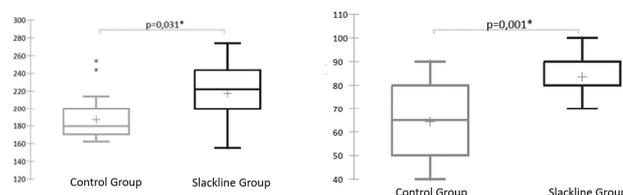


Figure 1. Inter Groups Comparison for both, attention, and visual memory tests.

**Correlation**

Finally, regarding the results of the correlation analysis, a  $r$  value = 0.710 was observed for the correlation between attention-concentration and years of slackline practice, evidencing a strong direct correlation. Regarding the correlation between visuospatial memory and years of slackline practice, a value of  $r = 0.332$  was observed, determining a moderate direct correlation (figure 2).

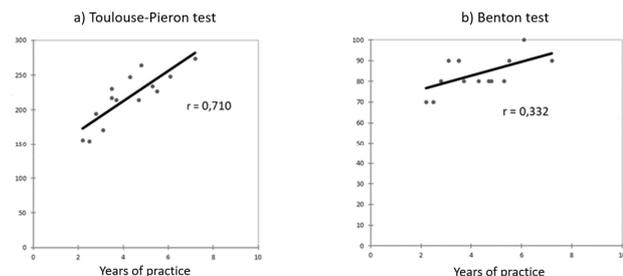


Figure 2. Correlation of attention and visual memory test scores with slackline practice years.

**Discussion**

The aim of this study was to determine the type of relationship between the years of practicing slackline and two cognitive functions: attention and memory, where it was determined that people who practice slackline obtained higher scores in visual memory and attention tests compared to people which do not practice slackline. In addition, a direct correlation was found between years of practice and attention and, to a lesser degree, with memory. These results are encouraging, as they show that a type of physical activity such as body balance training

could be a promoter executive function.

These results are in line with studies that have sought to propose non-pharmacological alternatives to enhance executive functions, such as applications called Games Brains created to train skills such as attention and memory (Sonuga-Barke et al., 2014). However, the evidence is still ambiguous in this regard, and although they achieve adherence and improve certain cognitive abilities, especially in the young population, they also manage to promote sedentary behaviors (Burleigh et al., 2020). In contrast to sedentary behaviors, the benefits of physical activity in the regulation of neurogenesis and angiogenesis through neurotropic factors in specific regions and structures of the brain are well known, allowing better health and cognitive performance in schoolchildren (Pulido et al., 2020). Considering the low cost of slackline practice, it could represent an alternative to generate sustainable public policies so that school-age children have access to physical activity. It is then where it becomes relevant to find therapeutic and prophylactic tools, which while maintaining the playful aspect to generate adherence, avoid harmful effects on health.

The high or strong relationship observed between years of slackline practice and attention could have implications in the treatment approach for people with attention deficit hyperactivity disorder (ADHD) since physical activity have shown to reduce ADHD symptoms such as impulsivity (Abramovitch et al., 2013).

It worth considered that capture the attention of hyperactive person is a challenge, therefore, enhance attention through physical activity it seems to be a feasible option, as Hippotherapy has demonstrated, which could be similar that slackline practice since both engaged motor control in response to an oscillatory stimulation (Oh et al., 2018). Interestingly, one study has established that children with ADHD present an alteration of the cervical-vestibular reflex (Isaac et al., 2017), which means this population has a poor control of body balance. Thus, slackline training could be useful to treat deficits in people with ADHD, without medications, improving corporal balance and the attentional network.

If we consider that the world population is aging, and with this an increase in the incidence of diseases such as Alzheimer's is expected, added to the greater risk of falls, body balance training could be preferred as an alternative to generate a functional reserve, and thus decrease both cognitive decline and the risk of falls (Eckardt et al., 2020).

In this line, there is evidence of other balance training practices able to influence cognitive performances, for instance disciplines such as Tai Chi have proven to be a promising alternative to reduce cognitive impairment (Shi et al., 2019), as well as to enhance physical skills such as body balance to reduce the risk of falls older people (Klein et al., 2019). Also, Taekwondo practice has proven to be effective in maintaining health and developing physical qualities, such as improving body balance, reducing the

risk of falls in older people (Linhares et al., 2022), while a dance program has been able to diminish the progress of cognitive decline in persons with Parkinson disease (Andreazza et al., 2022).

Although this study set a precedent regarding a direct relationship between sports practice of body balance and attention and memory, this does not imply a causal relationship, so future studies should carry out randomized controlled trials to determine whether the practice of slackline is responsible for generating these changes, as well as perform direct comparisons between different sports disciplines, especially those that exacerbate body balance. Furthermore, in addition to psychophysical tests, more direct test like molecular indicators, such as BDNF, could also be used to assess cognitive status and the potential development of cognitive functions.

## Conclusions

The results presented here allow us to suggest that the practice of slackline is related high level of attention and to a lesser degree with enhanced memory, allowing us to promote body balance training to enhance executive functions in healthy people to generate functional reserve to better face the typical cognitive decline of aging, as well as suggest that future research investigate the potential benefits of slackline training in children with ADHD.

## Acknowledgments

We wish to thank our volunteers, especially the slackline practitioners for the enthusiastic participation.

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