Ovidius University Annals, Series Physical Education and Sport / SCIENCE, MOVEMENT AND HEALTH
Vol. XXII, ISSUE 2 Supplement 2022, Romania
The journal is indexed in: ERIH PLUS, Ebsco, SPORTDiscus, INDEX COPERNICUS JOURNAL MASTER LIST, DOAJ DIRECTORY OF OPEN ACCES JOURNALS, Caby, Gale Cengage Learning, Cabell's Directories

Science, Movement and Health, Vol. XXII, ISSUE 2 Supplement, 2022
September 2022, 22 (2): 211 - 220
Original article

THE IMPACT OF PHYSICAL EXERCISE ON COORDINATION CAPACITIES AND BODY SCHEMA IN PEOPLE WITH DOWN SYNDROME

COSMA Germina Alina[1,2], BURILEANU Iulia[2], BURILEANU Alin[3], BĂZĂVAN Amalia[4], STEPAN Amalia- Raluca[5]

Abstract

Aim. The aim of this study was to analyse the relationships between physical exercise and coordination abilities and body schema in people with Down syndrome (DS).

Methods. The study was attended by 55 people with DS (aged between four and 44 years, M = 22.31, AS = 9.34) and their relatives, who answered the questionnaires (aged between 26 and 73 years, M = 49.22, AS = 11.21). Sociodemographic and personal data were measured based on a list of specific questions, and Interoceptive Awareness was measured with the Multidimensional Assessment of Interoceptive Awareness instrument.

Results. The results showed that the level of interoceptive awareness is higher in people with DS who perform sports exercises more frequently, while the knowledge of the specifics of DS and specific exercises by the people with DS are significant positive predictors of the level of interoceptive awareness of people with SD.

Conclusions. Our research carried out at the level of the PDS caregivers, highlighted the fact that people with DS frequently practice physical exercises, but present numerous deficiencies in terms of coordination, spatial-temporal orientation, and balance. They state that it is necessary for people with DS to benefit from exercise programs that intervene objectively on the three components studied (coordination, orientation, and balance) but also on the awareness of the body schema.

Keywords: Down syndrome, coordination abilities, interoceptive awareness, physical exercises.

Introduction

People with Down syndrome (DS) are much more likely to have problems with coordination and awareness of their body schema than typical people. But with the help of physical exercises and body awareness techniques, they can become much better able to coordinate their movements and gain a higher degree of self-awareness of their bodies. Down syndrome is the most common chromosomal abnormality (Weijerman et al., 2008) and is characterized by delay in mental development (Nichols et al., 2003, Seung and Chapman, 2004), clumsiness (Frith and Frith, 1974) and delays in motor development (Agiovlasitis et al., 2009, Rigoldi et al., 2011) and of the senses (Valkenburg, Tibboel, van Dijk, 2015, Brandt, 1996). Other studies have shown that, to the same extent, the processing of tactile perception, pain perception and hearing are affected (Nightengale et al., 2017, Jiang, Wu, Liu, 1990). As documented to date, sensory integration in people with DS relies more on the visual sense than on the other senses (Shumway-Cook, Woollacott, 1985). They are characterized by laxity and hypotonia (Pitteti, Climsteim, Mays, Barret, 1992). A study conducted by Hodges (1995) analyzed the way in which people with DS can give visual feedback, both in the presence and in the absence of a stimulus precursor, in a computerized test. The results indicated that the absence of the stimulus precursor attracted a higher number of errors and a much longer reaction time, leading to the conclusion that people with DS rely heavily on the presence of visual stimuli. Another study, led by Virji-Babul (2003) on 10 adults with DS and 14 typically developed people, involved the realization of a sequence of movements under two different visual information conditions: full visual feedback of the limb and environment and no visual feedback of the limb.

[1] Department of Theory and Methodology of Motor Activities, University of Craiova, Craiova, Romania
[2] Doctoral School of Social Sciences and Humanities, University of Craiova, Craiova, Romania
[3] Department of Kinetotherapy and Sport Medicine, University of Craiova, Craiova, Romania
[4] Doctoral School of Social Sciences and Humanities, University of Craiova, Craiova, Romania
[5] INCESA, University of Craiova, Craiova, Romania
CORRESPONDENCE AND REPRINT REQUESTS: Germina Cosma, Department of Theory and Methodology of Motor Activities, University of Craiova, Craiova, Romania. germina.cosma@edu.ucv.ro,

Their conclusion was that, as expected, adults with SD moved much slower, but, mean reaction and movement time was not affected by the visual condition, in either group. Another study conducted on 30 children with DS concluded that the use of virtual reality games led to the improvement of children's balance (Rahman, 2010). Another research on 40 newborns with DS, between 3 and 5 months, came to the conclusion that infants with Down syndrome performed less optimally than controls, but their movement patterns did not change due to the different exteroceptive experiences. Postural patterns, however, improved in infants with Down syndrome when exposed to the experimental mattress (Yardımcı-Lokmanoğlu et al., 2021).

Methods

The aim of the present study is to analyze the relationships between physical exercise and coordination abilities and body schema in people with Down syndrome (DS). Interoceptive awareness is also analyzed in relation to certain personal variables of people with DS.

Hypotheses

H1. The level of interoceptive awareness is higher in people with DS who perform sports exercises more frequently.

H2. The level of interoceptive awareness is higher in people with DS who perform specific exercises more frequently.

H3. Knowledge of the specifics of DS and specific exercises by the relatives of people with DS are significant positive predictors of the level of interoceptive awareness of people with DS.

Research design

The present study has a cross-sectional, descriptive, differential and correlational design.

Participants and procedure

The present study was attended by 55 people with DS (aged between four and 44 years, M = 22.31, AS = 9.34) and their relatives, who answered the questionnaire (aged between 26 and 73 years, M = 49.22, AS = 11.21). Regarding the participants with DS, 25 are male (45%), and 30 are female (55%), and regarding their relatives, four are male (7%), and 51 are female (93%).

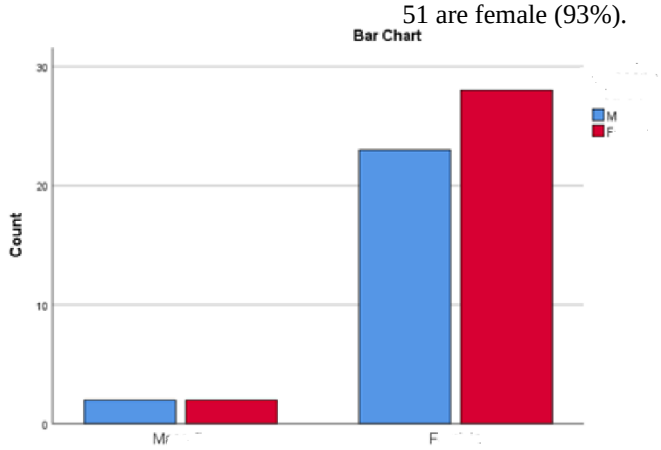

Figure 1. Distribution of participants according to gender of people with DS and gender of people with DS

According to the frequency of physical exercise, 10 people with DS say that they do such exercises only occasionally (18%), 14 do it once a week (25%), 17 do it three times a week (30%), and 14 do it daily (27%).

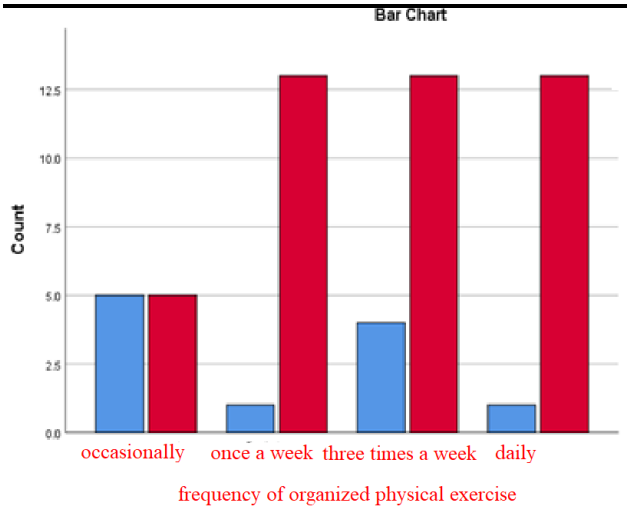

Figure 2. Distribution of participants according to the performance of organized physical exercises and their frequenc.According to the favorite sport of people with DS, 16 say they prefer ball sports (29%), 16 prefer gymnastics or dancing (29%), five prefer athletics and outdoor sports (9%), 10 prefer swimming (18 %) and eight prefer martial arts (15

The research was carried out between June and August 2022 and consisted of applying an online questionnaire, on the google.doc platform. The questionnaire was distributed in the network of the Down Syndrome Federation from Romania, a federation that includes 21 non-governmental organizations. The participants signed the informed consent, our research respecting the international ethical recommendations regarding the absolute confidentiality of the data collected in the study, as well as the anonymity and safety of the participants.

Instruments

Sociodemographic and personal data were measured on the basis of a list of questions regarding age, gender, sports performed or preferred, problems of balance, coordination and orientation of people with DS, the level of knowledge of the relatives regarding certain aspects related of the characteristics of people with DS, etc.

Interoceptive awareness was measured with the Multidimensional Assessment of Interoceptive Awareness (Mehling, 2018), a 37-item instrument with responses on a Likert scale from 0- Never to 5- Always. Example of an item: "When I feel tense, I notice in which part of the body the tension is located."

Descriptive statistics

Mean scores, standard deviations, internal consistency coefficients, and correlations between variables can be found in Table 1.

Figure 3. Distribution of participants according to gender and preferred sport

Table 1. Mean scores, standard deviations, internal consistency coefficients and correlations between variables

	M	AS	α	1	2	3	4	5	6	7	CI1	CI2	CI3	CI4	CI5	CI6	CI7	CI8	CIG
1	3.04	1.48	-	1															
2	3.18	1.39	-	.85**	1														
3	3.16	1.40	-	.69**	.80**	1													
4	3.42	1.44	-	.29*	.31*	.32*	1												
5	4.20	1.19	-	.29*	.18	.14	.43**	1											
6	4.07	1.25	-	.16	.05	.04	.32*	.26	1										

7	3.29	1.42	-	-.07	-.05	-.11	-.08	-.33*	1										
CI1	3.17	1.18	.83	-.13	-.08	-.03	.16	.02	.38**	.33*	1								
CI2	2.27	1.18	.88	-.00	-.03	-.08	-.16	-.09	.02	-.16	-.29*	1							
CI3	1.89	1.06	.80	-.17	-.17	-.10	.14	-.10	.13	.19	.28*	-.44**	1						
CI4	2.48	1.07	.88	-.14	-.18	-.08	.14	.02	.06	.33*	.61**	-.51**	.56**	1					
CI5	3.03	1.10	.89	-.09	-.07	-.06	.10	.08	.22	.42**	.56**	-.29*	.39**	.69**	1				
CI6	2.75	1.13	.83	-.10	-.04	.06	.23	-.06	.13	.37**	.49**	-.38**	.37**	.68**	.69**	1			
CI7	2.43	1.41	.96	-.20	-.11	-.02	.28*	.08	.17	.25	.49**	-.48**	.21	.55**	.50**	.71**	1		
CI8	3.46	1.03	.82	-.01	.03	.05	.23	.27*	.23	.14	.52**	-.15	.33*	.57**	.58**	.57**	.38**	1	
CIG	2.68	.71	.90	-.18	-.13	-.05	.24	.05	.28*	.38**	.75**	-.31*	.53**	.83**	.83**	.84**	.71**	.76**	1

**. p < .01, *. p < .05.

1. Balance problems, 2. Coordination problems, 3. Orientation problems, 4. Frequency of specific exercises, 5. Necessity of specific programs, 6. Knowledge of SD peculiarities, 7. Knowledge of specific exercises, CI1. Body observation, CI2. Nondistraction, CI3. Nonconcern, CI4. Regulation of attention, CI5. Emotional awareness, CI6. Self-tuning, CI7. Listening to the body, CI8. Trust, CIG.

Interoceptive awareness.

It is observed that the highest score is recorded for coordination problems, M = 3.18, AS = 1.39, followed by time-spatial orientation problems, M = 3.16, AS = 1.40 and balance problems, M = 3.04, AS = 1.48. Regarding the frequency of specific physical exercises, the score obtained by the participants is above average, M = 3.42, AS = 1.44. Relatives of people with DS strongly believe that there is a need for people with DS to benefit from specific physical exercise programs, M = 4.20, AS = 1.19. Regarding the knowledge of the relatives of people with DS of the characteristics of the syndrome itself, it registers relatively high scores, M = 4.07, AS = 1.25, and regarding the knowledge of the typical of specific physical exercises, the scores are average, M = 3.29, AS = 1.42. With regard to the dimensions of interoceptive awareness, the highest score obtained by people with DS is recorded for listening to the body, M = 2.43, AS = 1.41, and the lowest score for observing the body, M = 1.89, AS = 1.06. The global interoceptive awareness of people with DS registers average scores, M = 2.68, AS = .71.

Skewness and flattening fall within the range (-1, 1), which reflects a normal distribution of the data. This fact requires the use of parametric tests for statistical analyzes testing differences.

Inferential statistics

In order to organize the data and test the hypotheses, the statistical analysis program IBM.SPSS.25 (IBM Corp, 2016) was used.

H1. *The level of interoceptive awareness is higher in people with DS who perform sports exercises more frequently.*

To test this hypothesis, a one-way ANOVA analysis of variance was performed.

Table 2. Mean scores for the dimensions of interoceptive awareness according to the frequency of performing sports exercises

		N	M	AS	ES	95% IC Min.	Max.
Nonconcern	Occasionally	10	1.08	.85	.27	.47	1.69
	Once a week	14	1.80	.90	.24	1.28	2.32
	Three times a week	17	1.80	.95	.23	1.31	2.29
	Daily	14	2.67	1.03	.27	2.08	3.26
	Total	55	1.89	1.06	.14	1.60	2.18
Regulation of attention	Occasionally	10	1.96	1.05	.33	1.21	2.71
	Once a week	14	2.52	1.14	.30	1.86	3.18
	Three times a week	17	2.14	.64	.16	1.81	2.47
	Daily	14	3.23	1.11	.29	2.60	3.87
	Total	55	2.48	1.07	.14	2.19	2.77
Self-regulation	Occasionally	10	2.13	1.06	.33	1.37	2.88
	Once a week	13	2.90	1.13	.31	2.22	3.58
	Three times a week	17	2.40	.79	.19	1.99	2.80
	Daily	14	3.46	1.23	.33	2.76	4.17
	Total	54	2.75	1.13	.15	2.44	3.05
Body listening	Occasionally	10	1.63	.99	.32	.92	2.35
	Once a week	14	2.48	1.37	.37	1.69	3.27
	Three times a week	17	2.12	1.23	.29	1.49	2.75
	Daily	14	3.33	1.53	.41	2.45	4.22
	Total	55	2.43	1.41	.19	2.05	2.81
Trust	Occasionally	10	2.60	.91	.29	1.95	3.25
	Once a week	14	3.60	1.09	.29	2.97	4.22
	Three times a week	17	3.41	.90	.22	2.95	3.88
	Daily	14	4.00	.84	.22	3.52	4.48
	Total	55	3.46	1.03	.14	3.18	3.74

Table 3. One-way analysis of variance ANOVA for the dimensions of interoceptive awareness according to the frequency of performing sports exercises.

		Sum of squares	df	Mean of squares	F	Sig.
Body observing	Between groups	8.12	3	2.71	2.08	.12
	In groups	66.49	51	1.30		
	Total	74.61	54			
Nondistraction	Between groups	5.15	3	1.72	1.25	.30
	In groups	70.27	51	1.38		
	Total	75.42	54			
Nonconcern	Between groups	15.36	3	5.12	5.79	.00
	In groups	45.11	51	.88		
	Total	60.47	54			
Regulation of attention	Between groups	12.66	3	4.22	4.38	.01

	In groups	49.15	51	.96		
	Total	61.82	54			
Emotional awareness	Between groups	6.35	3	2.12	1.83	.15
	In groups	59.08	51	1.16		
	Total	65.42	54			
Self-regulation	Between groups	13.47	3	4.49	4.10	.01
	In groups	54.71	50	1.09		
	Total	68.19	53			
Body listening	Between groups	19.46	3	6.49	3.76	.02
	In groups	88.02	51	1.73		
	Total	107.48	54			
Trust	Between groups	11.77	3	3.93	4.45	.01
	In groups	45.00	51	.88		
	Total	56.78	54			

It is observed that five of the eight dimensions of interoceptive awareness show significant differences depending on the frequency of performing sports exercises.

Thus, for the absence of worry, the highest score is observed in people with DS who exercise daily, M = 2.67, AS = 1.03, followed by those who exercise three times a week, M = 1.80, AS = .95 , by those who perform once a week, M = 1.80, AS = .90 and finally by those who perform only occasionally, M = 1.08, AS = .85, the differences being statistically significant, $F(3, 51) = 5.79$, $p < .01$.

For attention regulation, the highest score is observed in people with DS who exercise daily, M = 3.23, AS = 1.11, followed by those who exercise once a week, M = 2.52, AS = 1.14, by those who perform three times a week, M = 2.14, AS = .64 and finally by those who perform only occasionally, M = 1.96, AS = 1.05, the differences being statistically significant, $F(3, 51) = 4.38$, $p < .05$.

For self-regulation, the highest score is observed in people with DS who exercise daily, M = 3.46, AS = 1.23, followed by those who exercise once a week, M = 2.90, AS = 1.13, by those who exercise of three per week, M = 2.40, AS = .79 and finally by those who perform only occasionally, M = 2.13, AS = 1.06, the differences being statistically significant, $F(3, 51) = 4.10$, $p < .05$.

For listening to the body, the highest score is observed in people with DS who exercise daily, M = 3.33, AS = 1.53, followed by those who exercise once a week, M = 2.48, AS = 1.37, by those who perform three times a week, M = 2.12, AS = 1.23 and finally

by those who perform only occasionally, M = 1.63, AS = .99, the differences being statistically significant, $F(3, 51) = 3.76$, $p < .05$.

For confidence, the highest score is observed in people with DS who exercise daily, M = 4.00, AS = .84, followed by those who exercise once a week, M = 3.60, AS = 1.09, by those who perform three times a week, M = 3.41, AS = .90 and finally by those who perform only occasionally, M = 2.60, AS = .91, the differences being statistically significant, $F(3, 51) = 4.45$, $p < . 05$.

Taking this result into account, we can say that hypothesis H1 is partially supported by the analyzed data.

H2. *The level of interoceptive awareness is higher in people with DS who perform specific exercises more frequently.*

To test this hypothesis, a one-way ANOVA analysis of variance was performed.

Table 4. Mean scores for the dimensions of interoceptive awareness according to the frequency of performing specific exercises

		N	M	AS	ES	95% IC Min.	Max.
Trust	To a very small extent	7	3.05	1.13	.43	2.00	4.09
	To a small extent	10	3.47	.93	.30	2.80	4.13
	Right	9	2.74	.66	.22	2.23	3.25
	Largely	11	4.00	.72	.22	3.52	4.48
	To a great extent	18	3.65	1.16	.27	3.07	4.23
	Total	55	3.46	1.03	.14	3.18	3.74

Table 5. One-way analysis of variance ANOVA for dimensions of interoceptive awareness as a function of frequency of performing specific exercises

		Sum of squares	df	Mean of squares	F	Sig.
Body observing	Between groups	2.42	4	.61	.42	.79
	In groups	72.19	50	1.44		
	Total	74.61	54			
Nondistraction	Between groups	4.22	4	1.06	.74	.57
	In groups	71.19	50	1.42		
	Total	75.42	54			
Nonconcern	Between groups	2.25	4	.56	.48	.75
	In groups	58.21	50	1.16		
	Total	60.47	54			
Regulation of attention	Between groups	3.58	4	.89	.77	.55
	In groups	58.24	50	1.17		
	Total	61.82	54			
Constientizare emotionala	Between groups	2.66	4	.67	.53	.71
	In groups	62.76	50	1.26		
	Total	65.42	54			
Self-regulation	Between groups	5.30	4	1.33	1.03	.40
	In groups	62.88	49	1.28		
	Total	68.19	53			
Listening to the body	Between groups	9.62	4	2.40	1.23	.31
	In groups	97.87	50	1.96		
	Total	107.48	54			
Trust	Between groups	9.69	4	2.42	2.57	.04
	In groups	47.08	50	.94		
	Total	56.78	54			

It is observed that only one of the eight dimensions of interoceptive awareness shows significant differences depending on the frequency of performing specific exercises, namely confidence. The highest score is observed in people with DS who perform specific exercises to a large extent, M = 4.00, AS = .72, followed by those who perform to a very large extent, M = 3.65, AS = 1.16, by those who perform to a small extent, M = 3.47, AS = .93, by those who perform to a very small extent, M = 3.05, AS = 1.13 and finally by those who perform to a suitable extent, M = 2.74, AS = .66, the differences being statistically significant, $F(3, 51) = 2.42$, $p < .05$.

Considering this result, we can say that hypothesis H2 is very little supported by the analyzed data.

H3. *Knowledge of the specifics of DS and specific exercises by the relatives of people with DS are significant positive predictors of the level of interoceptive awareness of people with DS.*

In order to test this hypothesis, a multiple linear regression analysis was performed with as predictors the knowledge of the specifics of DS and the knowledge of specific exercises by the people with DS and as the dependent variable the interoceptive awareness, calculated globally, as the average of its eight dimensions.

Table 6. Multiple linear regression analysis for knowledge of specific DS and specific exercises by relatives of people with DS as predictors of the level of interoceptive awareness of people with DS

Model	Unstandardized coefficients		Standardized coefficients		
	B	ES	β	t	Sig.
Knowledge of the particularities SD	.10	.08	.17	1.23	.22
Knowledge of specific exercises	.16	.07	.32	2.35	.02

$R^2 = .17$

It is observed that the two predictors are responsible for 17% of the variation in interoceptive awareness of people with DS, the regression equation being statistically significant, $F(2, 51) = 5.13$, $p < .05$. Of the two predictors, only one is significantly positively associated with interoceptive awareness, namely knowledge of specific exercises, $\beta = .32$, $t(55) = 2.35$, $p < .05$.

Taking this result into account, we can say that hypothesis H3 is partially supported by the analyzed data.

Discussion

A study that also investigated the involvement of people with DS in physical education and sports activities came to the conclusion that they first need the support offered by the family, then physical exercises adapted to their needs and coaches trained in this directive, and the challenge that sport can offer them, identifying themselves as winners (Alesi and Pepi, 2017). A follow-up study, during a period of medical monitoring of a young man with DS, over a period of 15 years, emphasized the success of the continuous practice of physical activity in specialized and sustained programs over long periods of time (Bricout et al., 2021). In the framework of another research carried out in the same direction, at the level of the answers recorded by the caregivers of people with DS, during 4 focus-groups, their conclusions regarding the practice of sports were the fact that all parents have confidence in the long-term effects of carrying out physical activities, many have observed that the motivation of people with DS at the beginning is to socialize, then, when they become teenagers, the parents consider it appropriate that there are no activities in which there is an adversary or people with whom the young people are forced to form a team, and the general conclusion remains in the increased need for personalized programs that can be practiced at home (Menear, 2007). Another research conducted on a group of 45 adolescents with DS, divided into an experimental group and a control group, participated in an intensive swimming program. The results showed that significant differences in all body mass indices in this specific group can only be achieved through a very ordered and long-lasting program (36 weeks of swimming/3 sessions of 50 minutes/week). Their conclusion would be that such programs should be introduced in all associations of people with DS (Suarez-Villadat, Luna-Oliva, Acebes, Villagra, 2020). Another cross-sectional study involving 35 adults with DS, which followed the measurement of the execution times of daily tasks, such as rising from a chair, concluded that physical fitness limits the ability of adults with DS to perform functional tasks of daily living (Cowley, 2010).

Conclusions

The research conducted identified the relationship between physical exercise, some components of motor ability and body schema in people with DS. With regard to the dimensions of interoceptive awareness, the highest score obtained by

people with DS is recorded for listening to the body, M = 2.43, AS = 1.41, and the lowest score for observing the body, M = 1.89, AS = 1.06. The global interoceptive awareness of people with DS scores average. Thus, it was found that people with DS frequently practice physical exercises, but have numerous deficiencies in terms of coordination, spatial-temporal orientation and balance. Also, the caregivers of people with DS strongly believe that there is a need for people with DS to benefit from specific physical exercise programs.

Acknowledgments

We would like to express our gratitude to all the PDS caregivers participating in this study. No funding was used for this study.

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