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The effect of dual play and use of dominant hand on the motility of the center of pressure while playing Timocco.

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1. Introduction

In the introduction we will present the population of children with Developmental Coordination Disorder (DCD), balancing abilities, interaction and play amongst the kindergarten population. We will also introduce Virtual Reality (VR) as a therapeutic tool and Timocco in particular.

1.1 Motor abilities of children with DCD.

DCD is a childhood disorder that is presents with poor coordination and clumsiness, and can significantly interfere with academic performance and/or activities of daily living. It is a neurodevelopmental disorder that does not affect the child's intellectual abilities. (APA, 2013). The prevalence of DCD in 5-11 year olds is estimated to be between 5%-6% and is more common in males than females. Children with DCD have more difficulties performing daily activities compared to their peers. (Summers, Lakin & Dewey, 2008). Even in the pre-school age group, there is a lower rate of participation in leisure activities of children with DCD. (Kennedy-Behr, Rodger & Mickan, 2011 ; Bart, Jarus, Erez & Rozenberg, 2011). Furthermore, they avoid participating in physical activities. This avoidance leads to decreased muscle strength (Markowitz, 2005). According to their parents' report, these children experience less enjoyment during play, leisure and social interactions (Bart et. al., 2011).
While using the Movement-ABC (M-ABC) assessment for motor abilities, an assessment for identifying children with DCD, it was found that children with DCD showed greater difficulties in fine and gross motor skills compared to their peers. Furthermore, they demonstrated difficulties in static and dynamic balance (Asinitou, Koutsouki, Kourtessis, & Charitou, 2012).

1.2 Balance, social interaction and play in 4-6 year olds.

Balance is the body’s ability to stabilize itself by keeping the center of gravity (COG) over the base of support (BOS) (Zumbrunn, MacWilliams & Johnson, 2011; Sobera, Siedlecka & Syczewska, 2011). Controlling the balance is vital for movement and motor abilities.

Center of pressure (COP) is an indicator of balance and postural control. The center of pressure is a point in time that represents the sum of all the forces that occur between the feet and the floor when standing (Doyle, Hsiao- Wecksler, Ragan & Rosengren, 2007). A correlation was found between the COP when standing in a balanced position to local dynamic stability while standing (Kang & Dingwell, 2006). Children need to stabilize themselves and move out of a stable position when participating in a social game. (Bar-Haim & Bart, 2006).

One of the ways to improve balance abilities in children is play. Children’s play is considered a reinforcing factor for physical, cognitive, creative and social abilities amongst children (Bundy, Luckett, Naughton, Tranter, Wyver, Ragen et. al., 2008). Play allows young children the opportunity to investigate their surroundings, to develop and improve different abilities such as: fine motor skills, gross motor skills, problem solving, emotional regulation and social interaction (Kennedy-Behr et. al., 2011).

During play, the children need to maintain positions that require control of their balance (Bar-Haim & Bart, 2006).

1.3. Virtual Reality (VR)

The field of computer games in general, and games that include VR technology specifically, is growing rapidly alongside the development of computers and the internet. (Hee Shin, 2009). VR is an artificial computerized reality that is presented to the end user by stimulating the different senses. The communication with the VR is done with a variety of sensing devices (keyboard, mouse, movement sensors and cameras). The feedback from the computer is via a visual, auditory and kinesthetic output. The VR technology allows the end-user to enter the virtual space created by the computer and take part in games that simulate real or imaginary worlds. (Olivieri, Chiappedi, Meriggi, Mazzola, Grandi, & Angelini, 2013).

It was discovered that using VR in therapy enhances learning by creating reoccurring contents that are focused on the specific activity the child has to perform. Additionally, it is possible to provide graded and personalized activities and feedback in a fun and safe environment, all of these are key motivators. (Ng, Chew, Samuel, Tan, & Kong, 2013).

In Tresser's article (2011), it was proven that while using a virtual game (Timocco), a child with avoidance patterns and difficulties with coping in social games was willing to try a variety of games and was able to enjoy playing with his peers in kindergarten. The virtual game gave him a sense of control, inner motivation and separation from the laws of reality. The game allowed him to enjoy the process and the game experience, a feeling that later led to an improvement in interaction with other children.

Timocco is a gaming platform based on VR technology. This platform was developed to merge interactive computer gaming and traditional therapy methods. The platform includes 48 games for children with developmental delays aged 3-14 and focuses on physical, cognitive and communicational abilities. Each game works on different skills. While playing the game, the therapist can control different parameters such as visual or audial distractions, difficulty level, range of motion and more in order to customize the game for each individual child. When playing Timocco, the child has to wear or hold one or two colored balls. Every movement the balls make is seen by the web-cam and is presented on the screen as movement. One of the targeted populations for this platform is children with DCD. Timocco allows them to practice and improve skills that they might have challenges with, for example, midline crossing, hand-eye coordination, bi-lateral coordination, balance, motor planning, sequencing and timing.

1.4 Purpose of current study

According to the literature presented above, children with DCD tend to avoid participating in different activities like social play and so on. Furthermore, they have trouble maintaining their balance due to their motor clumsiness. The technological advancement in computers has made VR technology advance rapidly. This kind of treatment has great potential to help children with DCD who have balance difficulties. It will force them to maneuver their COP outside their BOS in order to perform better in the games. It is possible that the integration of social interaction to the game will enhance the amount of motility the child performs and thus, enable the child to practice balance abilities. No earlier research that investigates how dual play and interaction between players while using VR affects motility of COP of children had been documented.

Furthermore, if the use of the dominant hand as opposed to the non-dominant hand affects the movement of the COP, therapists in a clinical setting could work with the children on balance and motility while playing Timocco in pairs by using the dominant hand.

1.5 Research questions.

1. Is there a connection between the motility of the COP while using the dominant hand as opposed to the non-dominant hand while playing Timocco?
2. Is there a connection between the motility of the COP when playing a dual game as opposed to playing alone on Timocco?

2. Methods

2.1 Participants

A total of 30 participants ages 5-7. The participants will be recruited in a convenience sample and snowball sampling. Criteria for inclusion: Normal developing, healthy developing children. Criteria for non-inclusion: children with developmental delays (ADHD, DCD, CP), children with untreated visual difficulties, children with difficulties understanding simple game rules and children whose parents reported familiarity with Timocco. The participants will be divided into pairs with the limitation that the height difference between them will not more than 15 cm (5.9 inch).

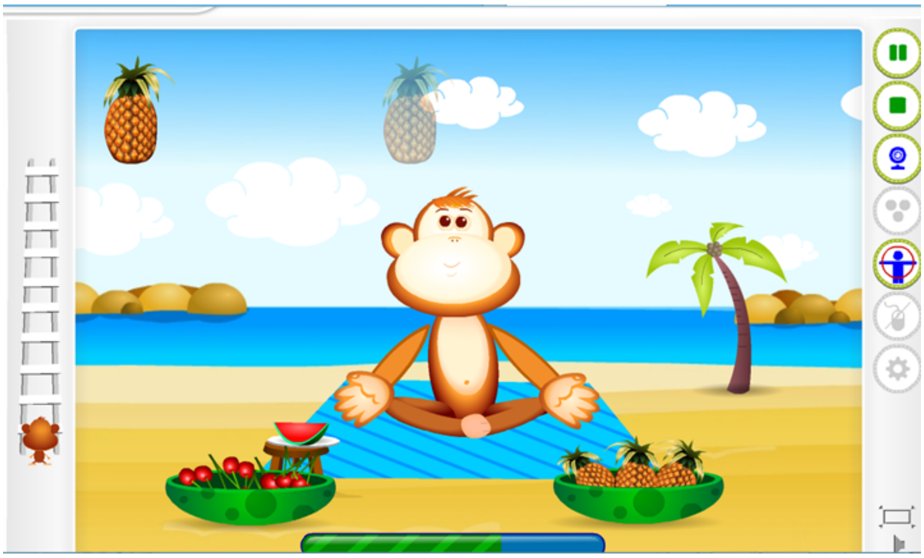
2.2 Measures

2.2.1 Parental Questionnaire

This questionnaire was built by the researchers and included eight sections. The parents were asked to fill in the questionnaire before the sessions were carried out. The questionnaire has questions about different parameters like height, weight and familiarity with Timocco.

2.2.2 Timocco

In this study, we will use a Timocco kit that includes a web-cam and two playing balls in different colors (red, green or blue) that can be worn on the hand like a glove. Each participant will hold one ball in their hand. Any movement they make with that hand will be recognized by the camera and exhibited on the screen. For this study, we chose two games, “Bubble Bath” for recognizing the dominant hand and “Falling Fruit” for the four measurements of COP movement.



2.2.3 Pressure Pad

A thin and flexible pad made of 256 pressure sensors (M-flex, 53cm X 53cm) allows accurate measurements of the pressure points between a person and the surface he is standing on. This technology gives information about the COP at any given moment.

2.3 Procedure

Upon their arrival, the parents will receive information about the aim and procedures of the research and will approve and sign a form allowing their child to participate in the research. They will fill in the parental questionnaire.

In every session, two participants will play together on the Timocco gaming platform after they get instructions on how to play the game. They will be asked to remove their shoes. Initially, each player will be tested separately. They will be asked to stand on a pressure pad in front of the game screen. They will be asked to stand on the pad without moving for 10 seconds to record their postural sway while standing in a static position. Then the child will play one game of “Falling Fruit” on the pad that allows the dominant hand to be facing the center of the screen.

During the personal test, the other participant will leave the room to avoid learning from watching the game. Later, both participants will be tested together. Child A will stand on the right pad and use his left hand to play while Child B will stand on the left pad and use his right hand. The participants are asked to reach as many fruits as possible. After one game, the children will be asked to switch pads and hands. After this, each child will be asked to play one more game of “Falling Fruit” using their dominant hand and on the same pad as the initial test. This is done to make sure that the results of a single game are not related to the order the games were played.

2.4 Data Analysis

The statistical analysis will be calculated in SPSS (21st version). First, we will check normality in frequentist statistics using the Shapiro-Wilk test. If the significance is higher than 0.05, the distribution will be normal.

3. Results

First we checked for statistical differences between the first and fourth test. It was found that there is no significant difference in COP motility in the following parameters: Horizontal axis (p=0.279), Anterior-posterior axis (P=.467), the distant that COP changed (P=.052). This shows that the results are not dependent on the order in which the games are played.

3.1 Participants’ information.

In the study, there were 28 healthy children from northern Israel. Four children were disqualified due to their young age and four more were disqualified due to technical difficulties. Thus, the information for the 20 participants of this test is shown below in Table 1.

Table 1 – Personal information of participants (n=20)

Age	6.05 (5.5-6.8)
Gender	11 female/ 9 male
Weight (kg)	**20 (17.25-22)**
Height	**110 (107.25-120)**
Hand dominancy	**Left handed/ 4 Right handed 16**

3.2 Dominance:

The results of the statistical analysis of the dominance are in Table 2. There were no significant differences in the motility of COP between the dual game with the dominant hand and the non-dominant hand.

Table 2: Dual play in dominant hand vs dual play in non-dominant hand

	Non-dominant hand	Dominant hand	P
Horizontal COP	20.61 (9.70-24.44)	16.86 (10.20-24.55)	.732
Vertical COP	8.50 (6.04- 12.36)	7.06 (4.34-14.28)	.560
Distance COP	89.20 (51.95- 140.65)	76.3 (41.35- 104.05)	.248

3.3 Single vs. dual play

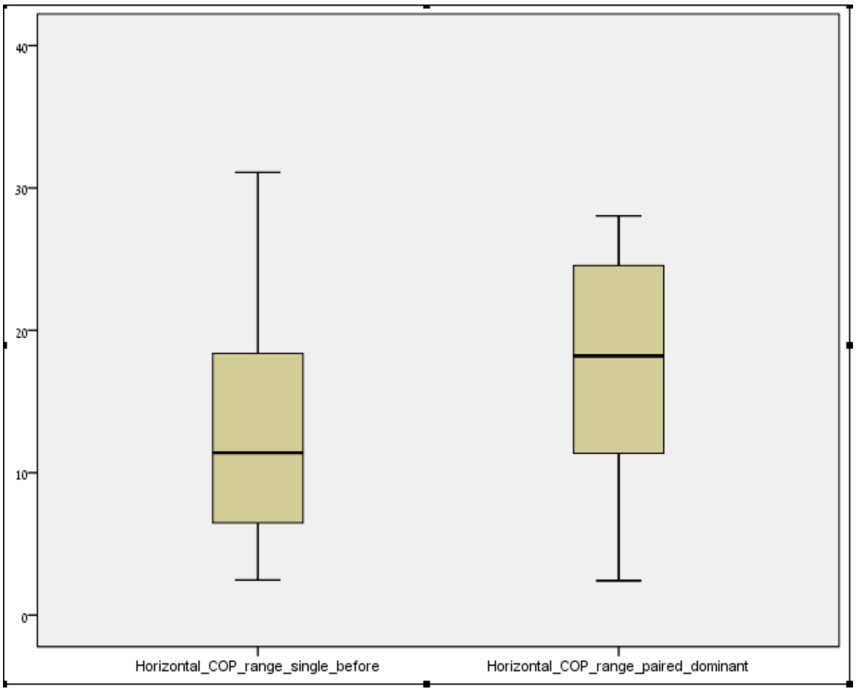
In the statistical analysis of a dual played game opposed to a game played alone, both with the dominant hand, the hypothesis was substantiated in regards to the horizontal COP as demonstrated in Table 3 and the graph.

Table 3: Single vs. dual play with dominant hand

P	Dual	Single	
Horizontal COP	16.86 (10.20-24.55)	12.14 (6.29- 22.54)	.37

Vertical COP	7.06 (4.34-14.28)	12.14 (4.29-22.54)	.296
Distance COP	76.3 (41.35- 104.05)	64.05 (43.32-98.10)	.135

Graph 1: Box plot of the horizontal axis in a single vs. dual play with dominant hand



Sources:

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders* (5th ed). Washington, DC: Author

Asinitou, K., Koutsouki, D., Kourtessis, T. &Charitou, S. (2012). Motor and cognitive performance differences between children with and without developmental coordination disorder (DCD). *Research in Developmental Disability*, 33, 996 1005.

Bar-Haim, Y, & Bart, O. (2006) Motor function and social participation in kindergarten children. *Social Development*, 15(2), 296-310.

Bart, O., Jarus, T., Erez, Y. &Rozenbers, L. (2011). How do young children with DCD participate and enjoy daily living. *Research in Developmental Disability*, 32, 1317-1322.

Beaumont, R., Sofrononoff, K. (2008). A multi-component social skills intervention for children with Asperger syndrome: the junior detective training program. *The Journal of Child Psychology and Psychiatry*, 49, 743-753.

Bundy, A. C., Luckett, T., Naughton, G. A., Tranter, P. J., Wyver, S. R., Ragen, J.,et. al. (2008). Playful interaction: Occupational therapy for all children on the school playground. *American Journal of Occupational Therapy*, 62, 522-527.

Christiansen, C., Abreu, B., Ottenbacher, K., Huffman, K., Masel, B., & Culpepper, R. (1998). Task performance in virtual environment used for cognitive rehabilitation after traumatic brain injury. *Archives of Physical Medicine and Rehabilitation*, 79, 888-892.

Deconinck, F. J. A., de Clercq, D., Savelsberg, G. J. P., van Coster, R., Oostra, A., Dewitte, G., et al. (2006). Differences in gait between children with and without developmental coordination disorder. *Motor Control*, 10, 125–142.

Demura, S., Kitabayashi, T. & Uchiyama, M. (2006). Body sway characteristics during static upright posture in young children. *Sport Science for Health*, 1(4), 158 161.

Doyle, R. J., Hsiao- Wecksler, E. T., Ragan, B. G. &Rosengren, K. S. (2007). Generalizability of center of pressure measures of quite standing. *Gait & Posture*, 25, 166-171.

Dunford, C., Missiuna, C., Street, E., &Sibert, J. (2005). Children's perceptions of the impact of developmental coordination disorder on activities of daily living. *British Journal of Occupational Therapy*, 68, 207–214

Elion, O., Bahat, Y., Sela, I., Siev-Ner, I., Weiss, P. &Karni.A. (2008).Postural adjustments as an acquired motor skill: delayed gains and robust retention after a single training session within a virtual environment. *Virtual Rehabilitation*, 50–53.

Hee Shin, D. (2009). The Evaluation of User Experience of the Virtual World in Relation to) Extrinsic and Intrinsic Motivation. *International Journal of Human- Computer Interaction*, 25, 530-553.

Hoffman, H. G., Doctor. J. N., Patterson, D. R., Carrougher, G. J., & Furness, T. A. I. (2000). Use of virtual reality for adjunctive treatment of adolescent burn pain during wound care: a case report. *Pain*, 85, 305-309.

Kang, H. G. &Dingwell, J. B. (2006). A direct comparison of local dynamic stability during unperturbed standing and walking. *Experimental brain research*, 172 (1), 35-48.

Kennedy-Behr, A., Rodger, S. &Mickan, S.(2011). Physical and social play of preschool children with and without coordination difficulties: preliminary findings. *The British Journal of Occupational Therapy*, 74(7), 348-354.

Lewis, G. N., Rosie, J. A. (2012). Virtual reality games for movement Rehabilitation in neurological conditions: how do we meet the needs and expectations of the users. *Disability and rehabilitation*, 34, 1880-1886.

Lott, A., Bisson, E., Lajoie, Y., McComas, J., &Sveistruo, H. (2003). The effect of two types of virtual reality on voluntary center of pressure displacement. *Cyber Psychology and Behavior*, 6, 477-485.

Markowitz, J. H. (2005). Dealing with Developmental Coordination Disorder. The *Israel Journal of Occupational Therapy*, 14 (4), 172- 176.

Mitchell, P., Parsons, S., & Leonard, A. (2007). Using virtual environments for teaching social understanding to adolescents with autistic spectrum disorder. *Journal of Autism and Developmental Disorders*, 37, 589-600.

Moore, D., McGrath, P., & Thorpe J. (2000). Computer- aided learning for people with autism- a framework for research and development. *Innovations in Education and Training International*, 37, 218-227.

Ng, Y. S., Chew, E., Samuel, G. S., Tan, Y, L., & Kong, K. h. (2013). Advances in rehabilitation medicine. *Singapore Medical Journal*, 54, 538-551.

Olivieri, I., Chiappedi, M., Meriggi, P., Mazzola, M., Grandi, A., & Angelini, L.(2013). Rehabilitation of Children with Hemiparesis: A Pilot Study on the Use of Virtual Reality. *BioMed Research International,* 2013, 1-5.

Pugnetti, L., Mendozzi, L., &Attree, E. (1998). Probing memory and executive functions with virtual reality: past and present studies. *CyberPsychology and Behavior*, 1, 151-162.

Riva, G., &Melis, L. (1997). Virtual reality for the treatment of body image disturbance*. Virtual Reality in Neuro-psycho-psychology*, G. Riva (Ed), 71-79.

Rothbaum, B. O. Hodges, L. F., Kooper, R., Opdyke, D., Williford, J. S., & North, M. (1995). Effectiveness of computer-generated (virtual reality) graded exposure in the treatment of acrophobia. *American Journal of Psychiatry,* 152, 626 628.

Rothbaum, B. O. Hodges, Alarcon, R., Ready, D., Shahar, F., Graap, K., Pair, J., Hebert, P., Gotz, D., Wills, B., & Beltzell, D. (1999). Virtual reality exposure therapy for PTSD Vietnam veterans: a case study. *Journal of Traumatic Stress*, 12, 263-272.

Schultheis, M. T., Rizzo, A. A. (2001). The application of virtual reality technology in rehabilitation. *Rehabilitation Psychology*, 46, 296-311.

Sobera , M., Siedlecka, B. &Syczewska, M. (2011). Postural control development in children aged 2-7 years old, based on the changes of repeatability of the stabilityindicies. *Neuroscience Letters*, 1(10), 13-17.

Summers, J., Larkin, D., & Dewey, D. (2008). Activities of daily living in children with developmental coordination disorder: Dressing, personal hygiene, and eating skills. *Human Movement Science*, 27, 215–229.

Yong Joo, L., Soon Yin, T., Xu, D, Tiha, E., Chia, PF., Kuah, CWK, et .al (2010). A feasibility study using interactive commercial off-the-shelf computer gaming in upper limb rehabilitation in patients after stroke. *Journal of Rehabilitation Medicine*, 42,437-441.

Zhu, Y. C., Wu, S. K. &Cairney, J. (2011).Obesity and motor coordination ability in Taiwanese children with and without developmental coordination disorder. *Research in Developmental Disability*, 32(2) , 801- 807.

Zumbrunn, T., MacWilliams, B. A. & Johnson, B. A. (2011).Evaluation of a single leg stance balance test in children. *Gait & Posture*, 32(2), 174-177.

אלבוים-גביזון, מ., אנגל-יגר, ב., וייס, ת., לויפר, י. (נובמבר, 2012). *השוואה בין רמת הביצוע במשחק מחשב וירטואלי בשתי קבוצות גיל של ילדים עם התפתחות טיפוסית.* הרצאה מכנס העמותה הישראלית להתפתחות הילד. ים המלח, ישראל.

טרסר,ש. (2011). תיאור מקרה: שילוב סביבת משחק וירטואלית "לגדול עם טימוקו", בטיפול התפתחותי ממוקד משחק בריפוי בעיסוק. *כתב עת ישראלי לריפוי בעיסוק*, 20, 229 .243