A COMPARISON OF TIME CHARACTERISTICS IN BALL CATCHING BETWEEN CHILDREN WITH AND WITHOUT DOWN'S SYNDROME

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BACKGROUND: The one handed catching of a ball is a complex coordination ability. It requires the spatial and time adjustment of the hand according to the speed of the approaching ball.

OBJECTIVE: Two main objectives were exposed in the course of the present research; namely whether and why children with Down's syndrome (DS) have problems with one handed ball catching compared to the children with no impairment in motor task such as the one handed catching of a ball.

METHODS: Eleven children with DS, aged 8, and 16 with no impairment, also aged 8, were required to catch 45 balls (small, medium, and large). No spatial uncertainty regarding the trajectory of the ball was present and therefore only time judgements were required to catch the ball.

RESULTS: The results of the present research showed that children with DS missed more balls than the children from the control group; the children with DS missed 30% of the balls vs. the children from the control group, who missed 7% of the balls. In addition, children with DS missed more small balls. The kinematic analysis of the time characteristics of one handed catching revealed that the difference in timing occurs at the time of grasping the ball. When examining the time of the catch in relationship to the time window, it can be seen that most children with DS tended to finish their catch too late.

CONCLUSIONS: Since differences were not found for the time of initiation and the time of maximal aperture, the present experiment suggests that it is not so much the anticipatory control but a slowness of movement that causes the higher percentage of catching failures in the children with DS.

Keywords: Children with Down's syndrome, one handed catching, kinematic analysis.

INTRODUCTION

Down's syndrome (DS) presents a unique etiology that affects many areas of development. Of specific concern are the motor delays and deviations that can affect the development of such areas as fundamental motor patterns, physical fitness and the learning of complex motor skills. The effects of DS on motor development have been widely reported over the years (Block, 1991; Thombs & Sugden, 1991; O'Brien & Hayes, 1995; Selikowitz, 1997; Schwartzman, 1999; Savelsbergh, Van der Kamp, Ledebt, & Planinsek, 2000). The goal of early work was largely descriptive and documentational in terms of what and when the differences between subjects with DS and individuals with no impairment occur. Recently, the more theoretical question of why and how the children with DS differ from individuals with no impairment has received at least as much attention.

Catching a ball is quite a complex coordination ability. It requires the spatial and time adjustment of the hand according to the speed of the approaching ball. To catch a ball successfully the hand has to be positioned at the interception point, followed by a spatial adjustment of the hand such that the ball makes contact with the hand in the metacarpal region, and the grasp has to be initiated and completed within a defined time window depending on the speed of the approaching ball. Failure to fulfil both gross and fine orientation results in spatial and time errors. The only report known to us in the literature with respect to catching performance in DS is the report by O'Brien and Hayes (1995). They found that the children with Down's syndrome did not perform as well as compared to other children with intellectual disabilities and children with no impairments in their intellectual development. One of the possible reasons might be that skills such as ball catching, where failure is so obvious, are considered to be unsuitable for children with intellectual difficulties and children with DS as well (Henderson, Morris, & Frith, 1981). Children with Down's syndrome also have problems with interceptive action (O'Brien & Hayes, 1995). Their study does not precisely specify whether this problem is due to spatial or time errors or both. Moreover, it also remains unclear whether this problem is due to perceptual (Do they perceive time to contact and what kind of information do they use?) or motor problems (Are they clumsier, slower?). Henderson, Morris and Frith (1981) have found that children with DS

have timing problems. It is worth mentioning that they were following lines on a paper being drawn by a pencil. So the performed task was quite different as compared to catching a ball. The DS afflicted individuals needed more time for their reactions than their coevals without DS or than those having other types of disorder of their mental development (Kerr & Blais, 1985; Weeks, Chua, & Elliott, 2000). Each movement appearing to be a response to some external stimulus comes with a slight delay. It gives the impression of acting in slow motion. The results obtained by Blais and Kerr (1985) show that individuals with DS reacted to a certain stimulus in 600 ms, while the control group needed only 300 ms, Cunningham (1999) stipulates that children with DS undergo considerable difficulties in the correct passing of objects. The ones that they get into their hands are far less "explored" – tasted, touched, observed, moved, etc. These children are also less skilled in placing their hands with regard to the shape and size of an object. In several articles concerning children with Down's syndrome (Henderson, 1985; Block, 1991; Latash, Kang, & Patterson, 2002) it has been reported that their motor performance is slower in comparison with children who have no impairment in their intellectual development or than those having intellectual problems.

Not many findings have been provided with respect to an environmentally valid task such as one-handed ball catching. It is this limitation, which justifies the present research. Therefore, the main goal of this research has been to examine whether and why children with DS do not perform as well compared to children with no impairment in a motor task such as one handed catching. More specifically, it is examined whether their worse performance in catching, as found in O'Brien and Hayes (1995), is due to different or worse time judgements (timing) or whether slowness of movement causes the higher percentage of catching failures in the DS impaired children.

METHOD

SUBJECTS

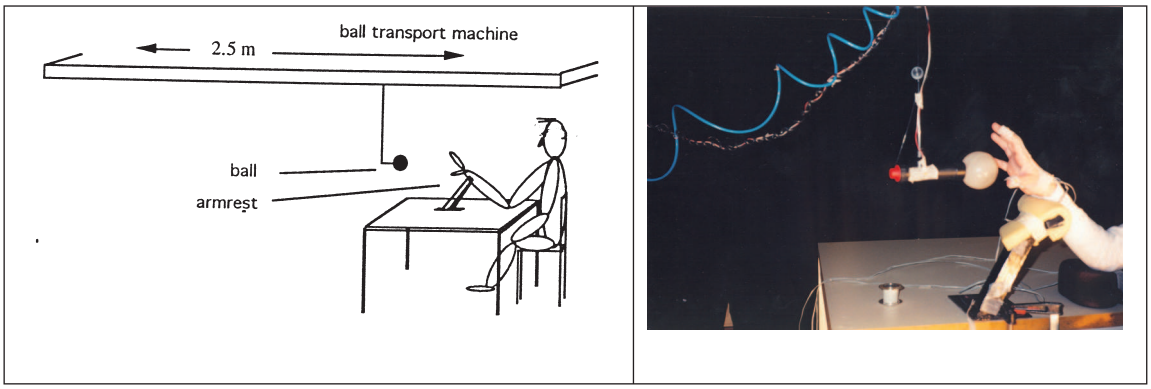
The sample consisted of 27 children aged 8 (+/–6 months). Among those were 11 children with DS (3 girls, 8 boys) and 16 with no impairment (3 girls, 13 boys). Children with no impairments are also referred as the control group. All of the children participated with their own and their parents' consent, and had no visual impairments.

PROCEDURE

Each child was assessed individually in an experimental room by the same researcher according to the Declaration of Helsinki. Subjects were required to catch 45 balls measuring 3 cm (small), 5 cm (medium) and 6 cm (large) in diameter. The balls were provided by the Ball Transport Apparatus (BallTrAP). The subjects were seated in the chair, next to the table and below the wooden box, at the end of the 200 cm straight path (Fig. 1a). The right wrist of the subject was fixed in the armrest, positioned on the table, so that only the movement of fingers was possible. Positioning of the hand ensured the hand to be in the path of the ball, so that the ball on the rod always swung into the hand of the subject. No spatial uncertainty regarding the trajectory of the ball was present and therefore only time judgements were required to catch the ball. Subjects were required to catch the ball between the thumb and the other fingers. The subject started each trial with the thumb and the index finger contacting each other. Each subject spent approximately 30 minutes to complete the experiment.

The kinematic characteristics of the catch were measured with the Selspot system. The camera was placed at a 110 cm distance, laterally from the subject,

Fig.1
Design of the apparatus and position of four LEDs



at the height of 110 cm. The Selspot system recorded four light emitting diodes (LEDs) positioned (Fig. 1b) on the end of the rod ("ball-LED"), on the wrist at the anatomical snuffbox ("wrist-LED"), as well as on the tips of the thumb and the index finger. Four reference LEDs with known distance were positioned in the same plane as the experimental LEDs on the hand and were used to calculate the distance between the experimental LEDs. The position signals of LEDs were sampled with a frequency of 156.4 Hz, and filtered by a second order Butterworth filter with a cut off frequency of 10 Hz.

The catching failures (i.e. the number of misses) and four variables, all of them being important to the timing of each catch, were analysed. The moment of ball hand contact was defined as the moment in which the distance between the ball-LED and the wrist-LED was minimal. Each catching trial produced the following kinematic variables:

- *The time of the initiation of the catch* (i.e. the distance between the thumb and the index finger starts to increase).
- *The time of maximal aperture* (i.e. the moment when the distance between the thumb and the index finger was maximal).
- *Peak closing velocity* (i.e. the maximal closing velocity).
- *The time of the catch* (i.e. the moment when the distance between the thumb and the forefinger was at minimum, depending on the ball size).

METHODS OF DATA ANALYSIS

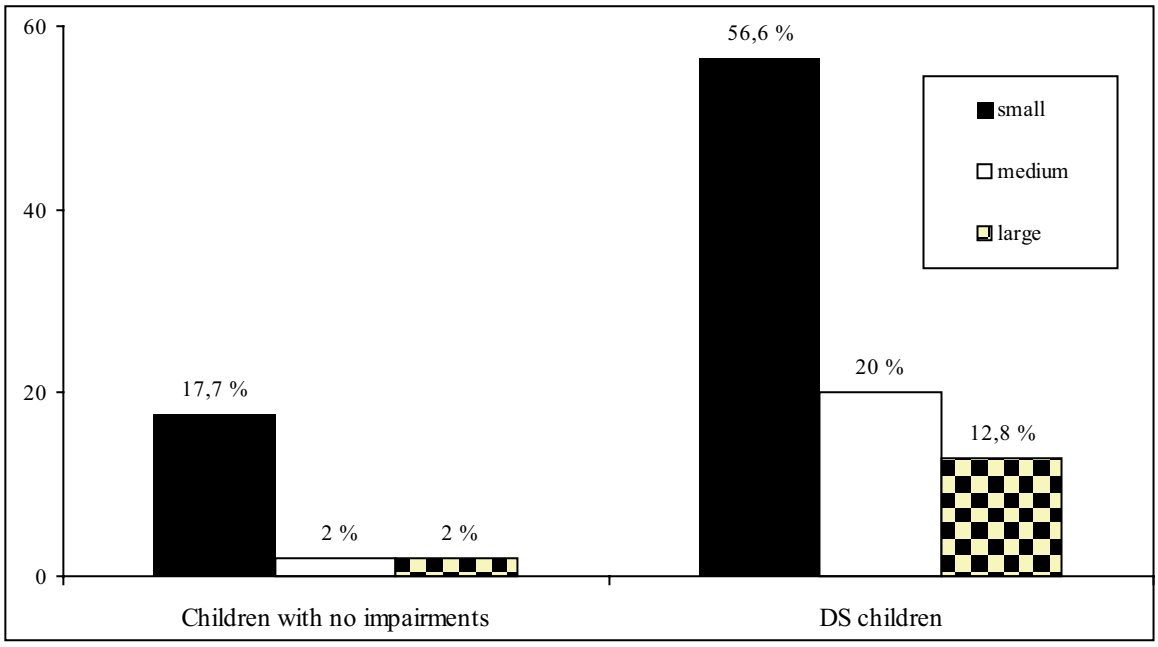
Descriptive statistics, the K–S normal distribution test and the analysis of variance (ANOVA) were carried out to compare the effect of the design of repeated measures on the last two factors. To identify differences between means, Newman-Keuls post-hoc comparisons were carried out (with $p < .05$). Data were processed with the statistical programming package SPSS for Windows (release 13.0).

RESULTS

Percentage of catching failures – misses

In the *percentage of misses* the significant main effect of a group was observed ($F [1.20] = 20.30$, $p < .001$). The DS children missed more balls than the children from the control group, ie. the DS children missed 30% of the balls vs. the children from the control group, who missed 7% of the balls. An interaction effect of ball size by group was found ($F [2.40] = 9.907$, $p < .001$) (Fig. 4). Post-hoc comparisons indicated that both groups missed more often with the small balls as compared to misses of balls of the other two sizes. In addition, the DS group missed the small balls more often as compared to the control group. The percentage of misses of different

Fig. 2
Percentage of misses of different sized balls among children with DS and children with no impairments



sized balls among children with no impairments and children with DS are presented in Fig. 2.

Kinematic analysis of the important time characteristics of catching

In analysing the time characteristics of catching, the results of the *time initiation of the catch,* the *time of the maximal aperture, peak closing velocity* and the *time of the catch* will be discussed. These values are also presented in TABLE 1.

TABLE 1
ANOVA for five kinematics' variables for DS and Control Group

Variable	GROUP	MEAN	SD	F	P
Time of the initiation of the catch	DS Control	–702 –789	166 152	2.0	.34
Time of the maximal aperture	DS Control	–241 –270	96 83	0.95	.49
Time of the catch	DS Control	57 21	19 7	2.65	.11
Peak closing velocity	DS Control	–395 –281	156 110	8.544	**.00**

Legend:
Time of the initiation of the catch, time of the maximal aperture and time of the catch are given in milliseconds (ms), while time of the peak closing velocity is given in mm/s. The minus sign indicates that the time is *before* the catch.

In analysing the time variables – the *time of the initiation* ($F[1.17] = 2.0$), the *time of the maximal aperture* ($F[1.19] = .95$) and the *time of the catch* ($F[1.19] = 2.65$) no significant main effects for a group were found, although the *time of the catch* approached significance ($p = .11$). TABLE 1 shows that the DS group tended to complete their catch later than the control group. Since the variance is also higher for the DS group, a t-test for the time of the catch was conducted. This (unrelated) t-test showed that the difference was almost significant, $t(19) = 1.63$, $p = .06$. Fig. 5 illustrates that the DS group tended to complete their catch later as compared to the control group. This was confirmed by the Mann-Whitney rank order test, which was proven to be significant, $U(19) = 78$, $p < .05$. This significant effect indicates that the DS children were catching balls later than did the children from the control group. When means of all trials together were plotted in the time window (Fig. 3), and two standard deviations were added (Fig. 4), it is clear that this tendency in the DS children, to catch the ball later, might result in more misses. It is evident from Fig. 3 that the DS subjects closed their hands later (the ball almost fell from their hands, about 100 ms after contact) compared to the control group subjects. Only one DS subject closed his hand too early. Three results of the subjects from the DS group and from the control group are presented in Fig. 4. It is seen that all three DS subjects were too late. This has also been confirmed by two standard deviations (SD) compared to the control group's subjects.

Fig. 3
Means of the time of the catch (7 DS and 14 control group subjects) in the time window

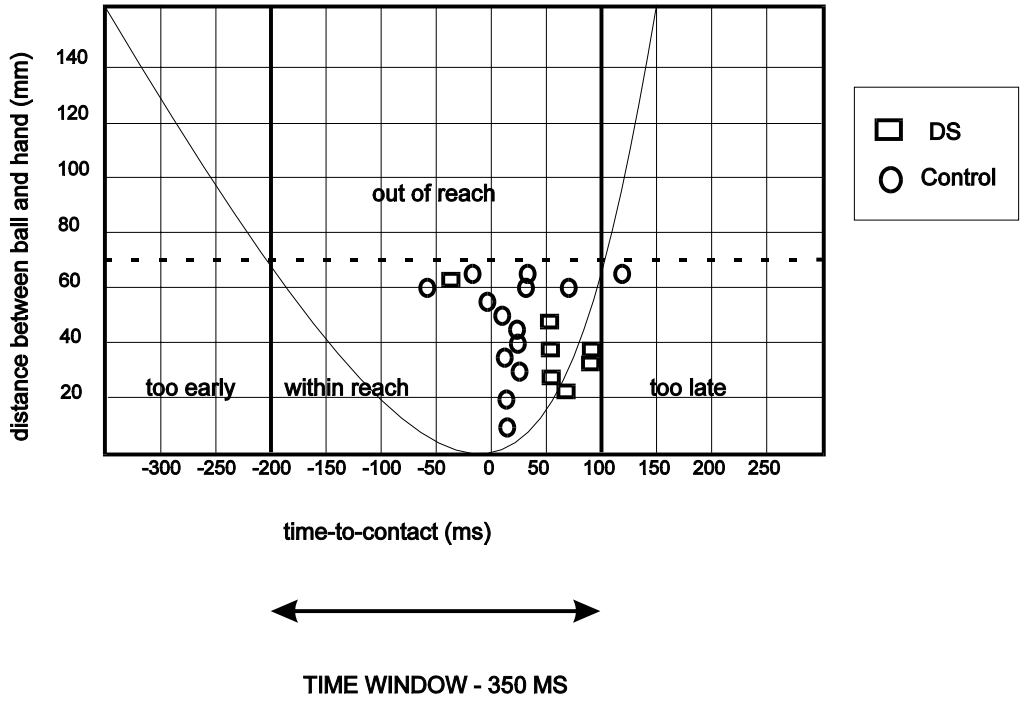
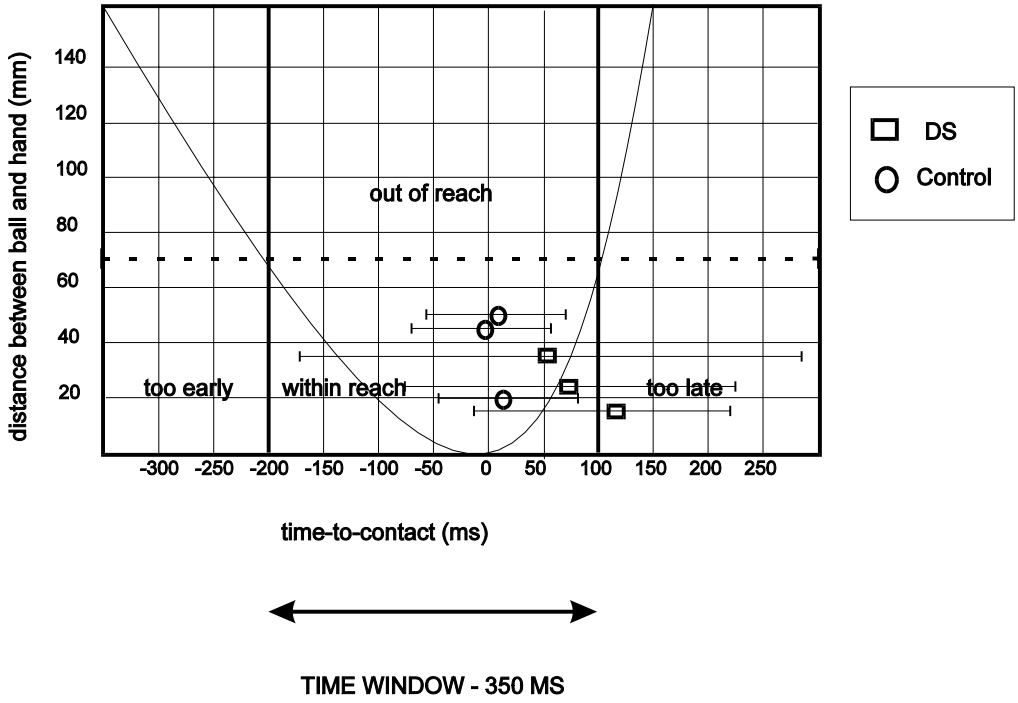


Fig. 4
Means and two standard deviations of the time of the catch (3 DS and 3 control group subjects) in the time window



A significant main effect of the group was found for the *peak closing velocity*, F (1.18) = 8.544, p < .01. The DS children closed their hands significantly faster compared to the children with no impairment (TABLE 1).

DISCUSSION

The general purpose of this study was to give an answer to the question whether and why children with DS aged 8 differ from children with no impairment aged 8 in a motor task such as one-handed ball catching where time predictions have to be made.

The results revealed that children with DS missed more often than did children with no impairment. It may be concluded that they are less successful in motor tasks with time constraints compared to their peers with no impairments. It should be stressed at this point that these findings are not surprising and are in line with the suggestions of other researchers (Henderson, 1985; Block, 1991; Thombs & Sugden, 1991; O'Brien & Hayes, 1995; Schwartzman, 1999; Polastri & Barela, 2005), who have pointed out that children with Down's syndrome perform less well than their peers, who with no impairment in intellectual development. More specifically, with respect to the time nature of the task examined, the findings are in agreement with Frith and Frith (1974), Henderson, Morris and Frith (1981) and Kerr and Blais (1985), who indicated that children with Down's syndrome have deficiencies in controlling the timing of their movement. Namely, Henderson et al. (1981) found the task of the catching of a ball too difficult for the DS children, and were not able to discover information about time characteristics in this specific motor behaviour task among the DS children. Therefore, they used a different kind of task that is a continuous tracking task. With respect to timing and information about timing in motor behaviour, tracking and catching tasks differ for the present study, as compared to a previous study. Together they offer only an opportunity for the comparison of results in two different tasks: tracking (Henderson, 1985) and catching a ball. Basically, the interest of both research projects is in the same domain. Unfortunately, there are no other studies reported with respect to catching a ball, but the data reported by Henderson et al. (1981) support our conclusions, namely problems associated with anticipatory movement tasks are due to time errors.

In order to find an answer to the question of why the DS children differed in catching performance, the kinematic analysis of the catch was carried out. It is seen that the DS children started opening and closing their hands almost at the same time as the children with no impairments, but they caught all balls of different sizes later. Especially the 3 cm balls were caught with a considerable delay. This is probably the reason why the DS children missed more balls than the control group did. This finding is consistent with the existing literature and clinical observations. Namely, the DS individuals perform slower than do their peers with no im-

pairments with respect to reaction and movement time (Henderson, 1985). The Henderson et al. study (1981) concluded that the DS children are impaired in using predictability in timing in order to control their movements by pre-programmed sequences. With the respect to the late catch found in the DS group, the question arises whether this is indeed a case of worse anticipatory control or a problem of slowness of movement. When examining the time of the catch in relationship to the time window (Fig. 3 and 4), it can be seen that most DS children, in contrast to the children with no impairments, tended to finish their catch too late. Since differences in timing were not found for the time of initiation and the time of maximal aperture, the present experiment suggests that it is not so much the anticipatory and timing control, but a slowness of movement, that causes the higher percentage of catching failures in the DS children.

CONCLUSION

The results of our research revealed that children with DS, aged 8 years, missed more often than did children with no impairments and, therefore, it can be stated that they are less successful in motor tasks such as one handed catching as compared to their peers. The kinematic analysis of the catch showed that children with DS started opening and closing their hands almost at the same time as the children with no impairments, but they caught all balls of different sizes later. Since differences in timing were not found for the time of initiation and the time of maximal aperture, the present experiment suggests that it is a slowness of movement which causes the higher percentage of catching failures in the DS children. Further research will continue in the field of the comparison of one handed catching performance among children with DS and with different intellectual disabilities, ages and gender.

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SROVNÁNÍ ČASOVÝCH CHARAKTERISTIK PŘI CHYTÁNÍ MÍČE U DĚTÍ S DOWNOVÝM SYNDROMEM A BEZ DOWNOVA SYNDROMU

(Souhrn anglického textu)

VÝCHODISKA: Chytání míče jednou rukou je dovednost s obtížnou koordinací. Vyžaduje prostorové a časové přizpůsobení pohybu ruky vzhledem k rychlosti přilétajícího míče.

CÍL: Tento výzkum měl dva hlavní cíle; totiž zjistit, zda a proč mají děti s Downovým syndromem (DS) problémy s chytáním míče jednou rukou ve srovnání s dětmi, jež nemají oslabené motorické dovednosti, například chytání míče jednou rukou.

METODY: Jedenáct dětí s DS, ve věku 8 let, a šestnáct bez poruchy motoriky, také ve věku 8 let, mělo

za úkol chytit 45 míčů (malých, středních a velkých). Hody byly stabilní, pokud jde o trajektorii míče, a proto k chycení míče byl potřeba pouze časový odhad.

VÝSLEDKY: Výsledky tohoto výzkumu ukazují, že děti s DS chytily méně míčů než děti z kontrolní skupiny; děti s DS nechytily 30 % míčů, zatímco děti z kontrolní skupiny nechytily 7 % míčů. Navíc děti s DS nechytily více malých míčů. Kinematická analýza časových charakteristik chytání jednou rukou odhalila, že rozdíl v načasování se vyskytuje v době sevření míče. Při posuzování doby chycení ve vztahu k časovému odhadu lze pozorovat, že většina dětí s DS měla sklon k příliš pozdnímu chytání.

ZÁVĚRY: Vzhledem k tomu, že nebyly nalezeny rozdíly u doby zahájení a doby maximální apertury, tento experiment naznačuje, že vyšší procento nechycených míčů u dětí s DS nemá na svědomí ani tak anticipativní kontrola, jako spíše pomalost pohybu.

Klíčová slova: děti s Downovým syndromem, chytání jednou rukou, kinematická analýza.

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