Eliciting Functional Extension in Prone Through the Use of a Game

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Objective. Although occupationally embedded exercise is becoming a recognized topic in occupational therapy research, study of this phenomenon in children has been limited. The present study examined whether play elicits therapeutic patterns of movement through the use of two ABA single-case experiments. It was predicted that in two children with hypotonic cerebral palsy, the addition of a favorite game to the occupational form, or treatment environment, would increase functional vertical neck and back extension.

Method. Each subject was positioned in prone on a wedge. During the A phases, each was given verbal directions to hold her head up. During the B phase, a favorite game was introduced. It was predicted that each subject would extend her back and neck in a functional way in order to manipulate and observe the game. The dependent variables were the mean range of neck extension and the mean range of back extension, which were measured by a videotaped, two-dimensional kinematic analysis.

Results. The addition of a favorite game to the occupational form improved vertical neck and back extension while discouraging nonfunctional neck hyperextension and fixing postures in both children.

Conclusion. Embedding exercise within a play occupation enhanced the prone extension of two children with hypotonic cerebral palsy.

Several researchers have found that adding purpose to an occupation can lead to improved performance, increased endurance, and resistance to pain. Kircher (1984) illustrated this effect by adding purpose (a jump rope) to the rote occupation of jumping. She concluded that "heart rate at a given rate of perceived exertion is significantly higher in the performance of a purposeful activity than of a nonpurposeful one" (p. 168). Steinbeck (1986) showed that the number of repetitions was significantly higher for persons performing a task in which a motivating goal was inherent in their performance than for those completing the exercise without the inherent purpose. Heck (1988) found a higher tolerance of pain in subjects engaged in a duplication of a pattern than in those asked to repeatedly trace an x on a piece of paper. Yoder, Nelson, and Smith (1989) looked at embedding exercise within an occupation to elicit a rotary movement of the arm. Subjects who were told that they were stirring cookie dough performed more repetitions than those who were asked to stir as long as they were comfortably able.
Researchers outside the field of occupational therapy have also studied the effect of purposeful occupation on performance. Van der Waal, van der Meer, and Lee (1991) found that the range of movement for children with cerebral palsy was significantly greater when the child performed the “concrete task” of banging drums with a drumstick as opposed to an “abstract task” of moving the drumstick back and forth. The authors’ explanation for this finding was in the added information the child received from the environment, such as visual, auditory, and tactile sensations; that is, “attainment of the goal was readily perceptible by the child” (p. 424).

Several figures in occupational therapy history have advocated the importance of purposeful occupations in normal development and as a therapeutic tool. For example, Baldwin (1919) stated that “the purposive nature of the movement and the end products of the work offer a direct incentive for sustained effort” (pp. 5–6). Russian psychologists Leontiev and Zaporozhets (1960) actively promoted occupational therapy in their country and wrote that an object-elicited occupation can often draw out therapeutic movements, whereas a verbal request cannot.

Gliner (1985) stated that purposeful occupations were necessary prerequisites for the formation of coordinative structures in human development. These structures are the bases for skilled movement according to the motor learning model of practice. Through play, a child begins to form coordinative structures essential for future skilled performances. A child also learns appropriate task skills and interactive behaviors (Olson, 1993). Alessandri (1949) stated that “play is a child’s way of learning and an outlet for his [or her] innate need of activity” (p. 9). Play is further defined as an occupation that is purposeful. However, many children with physical disabilities are often not actively able to participate in play occupations (Schoen & Anderson, 1993). Therefore, they are not exposed to the learning and developmental aspects that play occupations provide a child without disabilities. Gunn (1975) stated that “a deficiency in a person’s ability to play greatly impairs his [or her] ability to cope with novel, complex, and dissonant situations” (p. 225). Olson (1993) stated that the skills and behaviors learned through play become “the foundation for the ability to engage later in work” (p. 363). Therefore, children with motor dysfunction are at a disadvantage developmentally as well as cognitively, physically, and psychosocially.

Children with cerebral palsy show abnormal postural and movement patterns (Bobath & Bobath, 1964). The development of abnormal movement patterns is due to primitive postural reflex activity. This activity discourages balanced development of antigravity muscles, such as back and neck extensors (Connor, Williamson, & Stepp, 1978). The primitive postural reflexes also discourage head control. Unbalanced muscle tone and inadequate head control cause a lack of proximal stability from which to move (Connor et al., 1978). Children with cerebral palsy often have difficulty producing smooth movements because of lack of control or coordination. According to Anderson, Hinojosa, and Strauch (1987), “A primary goal of occupational therapy in treating children with cerebral palsy is to promote normal patterns of movement and prevent abnormal postural reactions while the child is engaged in functional, purposeful activities” (p. 421). Furthermore, because movements used in play are often similar to those used in other aspects of life, the use of play during treatment “may encourage the use of the same movements in other activities such as ADL [activities of daily living]” (Schoen & Anderson, 1993, p. 82).

To promote normal patterns of movement, Bobath and Bobath (1964) argued that basic postural movements are essential foundations for motor control. Levit (1995) stated that “the training of normal movement patterns includes the activation of postural responses that must be available on an automatic level for function” (p. 446). In functional terms, the promotion of postural stability is important if a child wishes to sit on the floor with his or her classmates to play a fast-paced game of “hot potato,” to don his or her shirt independently on the edge of the bed, or to ride the merry-go-round at the county fair. In other words, promoting normal patterns of movement could ultimately improve school, play, and ADL function. With a long-term goal of improved function, increasing functional neck and back extension, and thus improving proximal stability, can be incorporated into play for the short term.

According to Trombly (1989), the most basic postural pattern involves prone extension, which includes extension of the neck, trunk, shoulders, hips, and knees. Difficulty with extension and stability of the head, neck, and shoulders is evidenced in children with hypotonic cerebral palsy (Connor et al., 1978). To facilitate and strengthen the extensors, Ward (1984) recommended the prone position. Howson (1988) recommended that the pelvis be stabilized and lower than the head so that the child can voluntarily lift his or her head. This prone position can be more easily maintained by wedges or bolsters (Finnie, 1975). For these reasons, the subjects in our study were placed in the prone position. Not only did we want the subjects to engage in an occupation that was meaningful and purposeful for them, but we also wanted the occupation to facilitate functional skills.

On the basis of Nelson’s (1988) concepts of occupation, purpose must be elicited by the occupational form (i.e., by manipulating the environment) in order to encourage the occupational performance of functional.
neck and back extension. Adding a toy to the occupational form may provide this added purpose. Because the child is motivated by the toy to maintain neck and back extension, therapeutic and functional outcomes could be a result of the performance. Erhardt (1993) explained that "a child absorbed in play is not focused on the specific motor demand of the activity" (p. 451). She went on to claim that a child is motivated to use movements that will improve control of the head, trunk, and arms while manipulating toys.

An unpublished study guided the present experiment (Pylar, 1989). With an ABA single-case design, Pylar (1989) found that in a child with cerebral palsy the addition of a favorite toy to the occupational form generally elicited increased functional neck extension. Neck extension was measured as the duration of time in which the head was held above a specified level. The data showed that the subject generally held her neck in functional extension longer in the B phase when the toy was introduced than during either A phase without the toy. However, in discussing the results, Pylar reported several limitations. The major limitation occurred when the subject scored exceptionally high during one session in the second A phase for no explainable reason. Another limitation involved the termination of sessions before genuine fatigue set in. A range was determined that would allow for distinction between appropriate, purposeful neck extension and ineffective bobbing of the head, an indication of fatigue. When bobbing occurred and the head dropped below the predetermined range, the session was terminated. During the B phase, the subject showed such interest in the toy that rather than simply extending the neck, she made purposeful postural adjustments that led to bobbing of the head. This performance brought the subject's head below the predetermined range and led to termination of the session before genuine fatigue set in. We surmised that it may have been more important to measure the range of neck extension rather than its duration at or above a predetermined mark.

Therefore, in the current study, we desired to control the limitation of a predetermined range by controlling the duration of each session and measuring the height or range of neck extension. We planned to also measure the height or range of back extension. Increasing the height of neck extension without allowing extension of the back causes neck hyperextension. Hyperextension of the neck and elevation of the shoulders are considered nonfunctional posturing because this pattern interferes with arm movements (Scherzer & Tscharnuter, 1990). Therefore, to hold the head up higher, back extension should be involved in addition to neck extension. We explored whether a meaningful game would elicit a higher degree of functional vertical neck and back extension than would rote exercises in two children with hypotonic cerebral palsy.

**Method**

**Research Design**

Ottenbacher (1986) encouraged the use of single-case designs to study treatment and client outcomes and agreed that replication enhances the generalizability of the single-case design. Therefore, this study used the ABA single-case experimental design with two subjects. The A phases involved a verbal request to hold the head up. The B phase included the addition of a meaningful occupational form involving the use of each subject's favorite game. It was determined that each phase would end when a stable baseline became evident. A stable baseline was expected to take shape in approximately 10 sessions. The dependent variables were the mean range of neck extension and the mean range of back extension over a 2-min period.

**Subjects**

Regional educators and health care providers were contacted to aid in subject recruitment. The following selection criteria were used: (a) diagnosis of cerebral palsy and demonstrated hypotonicity in the neck and back extensions, (b) ability to understand and comply with verbal directions requesting motor activities with movements of the head and upper extremities, (c) sufficient visual skill to localize an object with both eyes, (d) sufficient range of motion to be able to reach the game, (e) ability to manipulate a game with the upper extremities, (f) prior demonstration of sustained interest in the game for 2 min, and (g) informed consent by the parents. The two subjects recruited were 10.6-year-old and 11.2-year-old girls. The therapeutic goal for each subject was strengthening neck extension.

**Apparatus**

Extension of the neck and back were measured by a videotaped two-dimensional biomechanical analysis with Motion Analysis, Inc., VP110 equipment. This technology analyzes the videotaped movements of reflectors placed on the subject's body. One reflector was positioned on top of the subject's head within the frontal plane passing through the highest part of the earlobe and an equal distance from each ear. A second reflector was placed over the seventh cervical vertebra, and a third was placed over the junction of the third and fourth lumbar vertebrae.

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1Manufactured by Motion Analysis, Inc., 3617 Westwind Boulevard, Santa Rosa, California 95403.
The computerized analysis digitized movements by assigning x and y coordinates at a rate of one frame per second over two 1-min intervals. The mean magnitude of neck and back extension was assigned to the y coordinate. An average height on the y (vertical) coordinate for each of the three reflectors was determined over the 2-min period. The average height of the C-7 reflector was subtracted from the average height of the reflector on top of the head to determine the range of neck extension. The average height of the C-7 reflector was subtracted from the average height of the lumbar reflector to determine the range of back extension. Total extension was determined by adding the ranges of neck and back extension.

Each session was videotaped with a camera mounted on a tripod and positioned 9 ft away from the subject and perpendicular to the movement analyzed. The subject was placed prone, supported from mid-sternum to neck and back extension was assigned to the y coordinate. The subject was placed upon mats, bringing the subject on the wedge and perpendicular to the movement analyzed. The subject was given the following directions:

The session was terminated after the 2 min had passed.

Procedure

Before the initiation of the study, each subject was asked individually to list her favorite games in order to identify a purposeful and meaningful occupational form. Both subjects noted “Hungry, Hungry Hippos” as a favorite. Each session began with positioning of the subject. Each subject was placed in a prone position on the wedge, as described previously, to provide trunk support. Sessions were conducted four times per week in the occupational therapy treatment room at the subjects' school, which is referred to in this article as the occupational form. During the A phases, a 6-in. diameter circle was placed on the wall 6 ft away from the subject at eye level when the neck and back were extended fully. During the two A phases the subjects were given the following directions:

Today, you are going to hold your head up and look straight ahead at the circle. I will time you for 2 min. Hold your head up for as much of the 2 min as you can. If you need a rest, drop your head and keep your arms down over the wedge. Do not put your elbows on the wedge. Do you understand? Ready, get set, go!

The session was terminated after the 2 min had passed. The first A phase continued until a stable baseline became evident through visual inspection of data after nine sessions.

The B phase introduced a favorite game, “Hungry, Hungry Hippos,” which was placed in front of the subject, 10 in. in front of the wedge, and 19 in. off the floor. This height required neck extension to manipulate and observe the game. The distance from the wedge allowed slight flexion at the elbow and forward reaching at the shoulders when the subject’s hands were placed on the activating lever. The object of the game was to catch as many marbles as possible through the hippo’s mouth. By pushing on the lever on the hippo’s back, its neck would extend, and its mouth would open. The player must continue to push the lever to open the mouth to “eat” the marbles. Verbal instruction protocol in this phase was as follows:

Today, you are going to play a game. You will play the game for 2 min and try to catch all the marbles. While you play, you should keep your head up and not tilted to the side. Use both hands; do not use the rest of your body. If you need a rest, drop your head and keep your arms down over the wedge. Do not put your elbows on the wedge. Do you understand? Ready, get set, go!

The B phase lasted until stable results were found after nine sessions.

The second A phase was carried out in the same manner as the first A phase. It was continued until a stable baseline became evident after nine sessions.

Four of the planned sessions in the first A phase were interrupted between Sessions 6 and 7 for each subject because of school spring break. This break appeared to have little effect on either subject’s performance. Subject 1 also missed three consecutive planned sessions between Sessions 3 and 4 of the B phase because of illness. On visual inspection, little change can be attributed to the interruption. All of these breaks occurred within phases, not between phases; therefore, they do not detract from the inferred validity of the study.

Results

Subject 1

Figures 1A through 1C shows the results of Subject 1, which clearly demonstrate the effectiveness of treatment. Neck, back, and total extension elicited during the B phase resulted in higher vertical distance measurements than all 18 sessions of both A phases. There was no overlap of data points between the A and B phases with the back extension variable and total extension, and only a slight overlap of data points with the neck extension variable (Sessions 2 and 16). Eight of the 9 B (treatment) sessions were greater than 17 of the 18 A (no treatment) sessions for both neck and back extension and for total extension.

During the first A phase, the height of neck and back extension fluctuated slightly from session to session, with a notable decrease in Session 7, which fell on the first day back after spring break. The mean score for was -3.78 cm for neck extension, .07 cm for back extension, and -3.71 cm for total extension. On visual inspection,
the individual session scores in the first A phase fluctuated at or around the 0 cm mark. However, the mean score for neck extension was negative because of the low score in Session 7. The positive score for back extension was due to the angle of the wedge the subject was lying on.

The B phase started with Session 10, following a relatively stable baseline establishment. The height of neck, back, and, therefore, total extension each increased at the beginning of the phase and were maintained at a relatively stable level. The mean height for neck extension was 7.09 cm for neck extension, 7.75 cm for back extension, and 14.84 cm for total extension.

During the second A phase, Subject 1's neck, back, and total extension decreased again, quickly declining and then stabilizing. The mean scores were -5.43 cm for neck extension, -0.58 cm for back extension, and 6.01 cm for total extension.

Subject 2

Figures 2A through 2C shows the results for Subject 2, which also demonstrate the effectiveness of treatment. For back extension, stable baselines were present in both A phases, with an increase in magnitude and a change in slope during the B phase. There was only one overlap of data points between the A and B phases. For neck extension, there was more overlap of data points, yet there was still an observable change in slope and magnitude. The same is true for the total extension scores. Furthermore, the mean scores for each form of extension in each phase suggest a difference across phases in a positive direction.

During the first A phase, the height of neck, back, and total extension fluctuated from session to session. The mean scores were 9.66 cm for neck extension, 3.13 cm for back extension, and 12.79 cm for total extension.

The subject showed an increase most notably in back and total extension during the B phase. Although neck extension increased in the first session of this phase, it dipped slightly lower than the three highest scores of the initial A phase. However, the mean neck, back, and total extension scores in the B phase were each higher than the mean scores during the first A phase. The mean scores were 11.88 cm for neck extension, 8.15 cm for back extension, and 20.03 cm for total extension.

During the second A phase, the subject's extension decreased again, with marked fluctuations from session to session. The first session of the final stage showed a neck extension score that was slightly higher than several of the B phase scores. However, after this first session, neck extension decreased markedly, and the scores remained relatively low. The mean scores were 8.12 cm for neck extension, 2.78 cm for back extension, and 10.90 cm for total extension.
Discussion

The results supported the prediction that with the addition of a meaningful game to the occupational form, a higher degree of vertical neck extension was elicited. In addition, this occupational form also elicited greater back extension. The greater back extension discouraged neck hyperextension, encouraging a functional extension pattern while in prone. This concept was evident with both subjects' performance. Subject 1 spent much of the 2 min of the A phases resting with her head hanging down, which led to some of the negative vertical distance numbers for neck and total extension. However, when presented with her favorite game, she was motivated not only to hold her head up, but also to use her back extensors to elevate her head and trunk higher in order to manipulate and observe the game. As Erhardt (1993) explained, in play, a child is not focused on specific motor demands and is motivated to use movements that will improve head and trunk control. Subject 1 was motivated to contract her neck and back extensors to elevate her head in order to observe how she was manipulating a game and did not complain of fatigue with the specific motor demands as she had during the A phases.

For Subject 2, the addition of a game to the occupational form also elicited a functional movement pattern. Although she was motivated to hold her head up as high as she could during the A phases, she accomplished this primarily through neck hyperextension, shoulder elevation, and pectoralis contraction by pressing her arms against the wedge. Although this posture allowed Subject 2 to raise her head, it was not a functional pattern because it interfered with, and in fact inhibited, arm movement. However, with the introduction of the game in the B phase, back extension increased in a higher proportion than neck extension. Although neck extension was apparent in the A phases, the back extension elicited by the game in the B phase nearly doubled the total extension that the subject was able to achieve.

The addition of the game to the occupational form provided added purpose to encourage each subject into neck and back extension. The maintenance of this extension could result in therapeutic outcomes. The maintenance of neck and back extension will allow for strengthening of these extensor muscles, providing improved proximal stability (Connor et al., 1978). With a more stable base of support, a child can become more involved with his or her environment through exploration and play beyond the base of support. This increased involvement exposes a child to more of the physical, cognitive, psychosocial, and developmental aspects of play that Alessandrini (1949) and Gunn (1975) described. For these reasons, occupational therapists should attempt to elicit the maintenance of neck and back extension in order to enhance a child’s development as well as current
function. According to the results of the present study, simple requests for neck extension apparently led to the child focusing on the specific motor demand, causing lack of motivation and leading to fatigue. Hence, there was an inability to maintain the prone extension posture. Furthermore, this study demonstrates that with verbal directions alone, the elicitation of a nonfunctional fixing pattern is possible, leading to a posture that does not allow for arm movement and that creates an imbalance between flexors and extensors. Most importantly, this study demonstrated the necessity of adding meaning (in the form of a game) to the occupational form. This added meaning elicited motivation to maintain the prone extension posture without the use of nonfunctional, and possibly detrimental, fixing postures. Additionally, this added meaning elicited a natural play response: The subjects were not focused on the specific motor demands of the task.

Although the present study demonstrated the effectiveness of a purposeful occupation on eliciting sustained and functional performance, some limitations can be noted. A research limitation inherent to working with children in school systems involves vacations and unplanned sick days. Because of the length of the study, these disruptions were unavoidable. Subject 2’s spring break fell in the middle of the first A phase but with no apparent disruption to her performance. Subject 1’s performance after returning from the spring break remained relatively stable with regard to back extension. However, neck extension fell below previous performance. Overall, neck extension appeared stable after nine sessions, and in the B phase, neck, back, and total extension improved. Furthermore, Subject 1 missed three consecutive planned sessions between Session 3 and 4 of the B phase because of illness. However, little change was noted as a result of the break, and the interruption did not appear to affect performance (see Figures 1A–1C). This study was also limited by the first author’s involvement in the data collection, despite the use of an objective measurement method.

Although the ABA design’s strength lies in its final A phase in determining whether the intervention was the factor causing change—not history or maturation—a potential limitation of the ABA design is that it ends with a baseline phase, leaving the subject without treatment (Ottenbacher, 1986). One solution to this problem is the reintroduction of the B phase, creating an ABAB design. Although a fourth phase was not possible because of the time limitations of the present study, continuation of the treatment was recommended to the subjects’ occupational therapists.

The second A phase for both subjects is marked by a clear decrease in neck and back extension. With both subjects, the first session of this phase did not show a large decrease in extension; therefore, it could be said that there might be a carryover effect of the treatment. Long-term effects were beyond the scope of the present study, and the presence of a short-term effect neither negates nor demonstrates long-term effects. Although the present study documents short-term effects of treatment, the long-term effects could be dealt with in future studies. It is recommended that a multiple baseline design be used to look at the long-term effects a game can have on eliciting neck and back extension. Strengthening could also be studied. The present study brings to light additional questions suitable for inquiry. An important question is whether this study’s method of encouraging neck and back extension will produce results that will carry over into the ADL performance area. A replication of this study could be conducted, investigating the quality of neck and back extension in the no-purpose phase versus the occupationally embedded, game phase. Finally, with the use of motion analysis, an important basic research question involving the movement patterns of children with cerebral palsy compared with the those of children without disabilities could be investigated.

The results of this study reinforce the field of occupational therapy’s basic beliefs that purposeful occupations provide incentive for sustained effort (Baldwin, 1919). Like Kircher (1984), Steinbeck (1986), and Yoder et al. (1989), this study found that adding purpose to an occupation led to improved performance. This study not only contributes to the occupationally embedded exercise literature within the field of occupational therapy, but also contributes to the fields of human development, pediatric therapy, and child psychology. Furthermore, the method of data collection and analysis used in this study is innovative to the field of occupational therapy. The continued application of motion analysis will lead to more detailed and sensitive awareness of human movement in different occupational forms.

Conclusion

The results of this study demonstrate that the addition of a meaningful and favorite game to the occupational form elicited a higher degree of functional vertical neck and back extension in two children with hypotonic cerebral palsy. The use of purposeful occupation as a method to enhance meaning and performance has been at the core of the field of occupational therapy since its founding.

This study is unique because it reinforces the idea of occupationally embedded exercise in a population that has not been considerably researched with regard to this phenomenon. Furthermore, with the use of motion analysis, this study introduces a quantitative, biomechanical, and kinematic approach to occupational therapy research.
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References


