Heart Rate, Activity, Duration, and Affect in Added-Purpose Versus Single-Purpose Jumping Activities

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Key Words: activity analysis • fatigue • motivation • physical endurance

This research replicates and extends an occupational therapy research project reported by Kircher in 1984. Thirty women aged 18 to 31 years jumped with a rope on one day and jumped in place on another day in a counterbalanced design. Each subject stopped jumping when she reached what she perceived as the very hard level on the Borg Scale of Perceived Exertion (Borg, 1970). Differences from Kircher’s design included an imposed target zone formula for safe maximum exertion, use of a portable, more easily read heart rate monitor (Exersentry, Model 3), use of the Osgood Semantic Differential to measure affective meanings, and asking the subjects to identify the type of jumping they preferred. Data analysis supported Kircher’s finding that at the given rate of perceived exertion, heart rate increase after jumping rope was significantly higher (p = .01) than after jumping without a rope. The difference in duration of jumping approached significance (p = .06), but in the direction opposite to what Kircher found. There were no significant differences in affective meanings or preference. Results are discussed in terms of the need for a growing body of occupational therapy literature in regard to the purposefulness of activities.

An important feature of occupational therapy is the therapeutic use of purposeful activities to promote, maintain, and restore health. Purposeful activity, according to Mosey (1981), has been a part of the profession from its beginnings and is a legitimate tool for occupational therapy. Fidler and Fidler (1978) stated that occupational therapists wishing to use purposeful activities must have expertise in activity analysis and know the who, what, why, where, and how factors of each activity. Occupational therapists need to delineate, classify, and analyze purposeful activities in terms of their potential, taking into consideration the motor, sensory, psychological, cognitive, interpersonal, social, and cultural requirements of the activities, as well as the structural characteristics of humankind and the principles of behavioral change (Cynkin, 1979; Fidler & Fidler, 1978; Trombly, 1983). The consideration of all of these factors will contribute to increasingly effective treatment.

According to Florey (1969), carefully selected activity brings satisfaction and pleasure to the client, and these factors sustain therapeutic movement in the midst of pain. She also noted that “pleasure in the activity itself is a key property of intrinsic motivation” (p. 320). Reed (1984) stated that involvement in a preferred activity will turn a patient’s attention away from pain, confinement, or the healing process. Trombly (1983) wrote that purposeful activity may facilitate movement because the patient does not anticipate pain or may motivate the patient to remain engaged in repetitive exercise for relatively long pe-
periods of time. In a research study, Gal and Lazarus (1975) found that activity is effective in reducing anxiety and distress and concluded that it is a healthy coping mechanism that diverts attention from pain and stress.

Given the importance of the concept of purposeful activity to the profession, there is need for research by occupational therapists in this area. Specifically, as Trombly (1982) stated, "Special attention has to be given to research comparing effectiveness and efficiency of activity versus exercise to restore the patient to as high a level of functioning of which he or she is capable, a goal all OTRs hold in common" (p. 467). In like vein, after noting that the use of purposeful activity in occupational therapy depends on a number of assumptions about the meaning and use of activities, Fidler (1981) declared that "the description or testing of those assumptions is long overdue" (p. 569).

**Background**

Kircher (1984) examined whether purposeful activity provides motivation for exercise. She identified jumping with a rope as a purposeful activity and said it "could be described as 'fun' and, in doing it, one's initial focus is likely to be on the rhythm and synchrony of the upper and lower extremities and manipulation of an object" (p. 166). Kircher labeled jumping without a rope as nonpurposeful and indicated "the mental focus is likely to be on jumping itself and physical exertion" (p. 166). In a sample of 26 healthy young women, Kircher found that heart rate at a given level of perceived exertion was significantly greater ($p = .001$) for the purposeful activity (jumping rope) than for the nonpurposeful activity (jumping without a rope). Exercise duration was also in the hypothesized direction (longer for the purposeful activity than for the nonpurposeful activity), but the difference was not statistically significant. Given these results, Kircher suggested that exertion and fatigue were perceived to be less during jumping with a rope than in the other condition. She argued that these results indicated enhanced motivation by subjects engaged in the purposeful activity.

Citing Kircher, Steinbeck (1986) investigated two different purposeful activities, a Ping-Pong ball game involving an upper extremity and a woodworking activity, employing a pedal-powered drill press, primarily involving the lower extremities. Comparison exercises were performed with similar apparatus but did not involve woodworking or a Ping-Pong ball. Following Kircher, Steinbeck labeled these exercises "nonpurposeful." He found that the number of repetitions in both purposeful activities exceeded the number in the nonpurposeful activities at significant levels. As with Kircher's jump-rope activity, the rate of repetitions was not controlled for in the Ping-Pong ball activity, and this activity elicited significantly higher heart rate than the nonpurposeful comparison exercise. However, in the pedaling activities, the rate of pedaling repetitions was controlled for with a metronome, and the difference in heart rate was in the opposite direction (the nonpurposeful activity elicited the higher heart rate).

The present study, designed and executed before Steinbeck's results were published, is a replication and extension of Kircher's study. Jumping with a rope (JWR) is compared with jumping without a rope (JWOR) at a given level of exertion in terms of heart rate and duration. Replicability is an essential feature of scientific research, and results should be considered tentative until they are successfully replicated (Kerlinger, 1964). Mann (1987), in a discussion of replication, noted the dearth of replication studies in occupational therapy and concluded that "practice must be grounded in theory and carefully tested and retested through research" (p. 128).

Ideally, replication takes place under near-identical conditions except for the physical location. Although the design of this study was similar to Kircher's, an imposed heart rate target zone for safe maximum exertion (Wilson, Fardy, & Froelicher, 1981) was enforced because occupational therapists are interested in patterns of aerobic exercise that are within recognized safety limits. In addition to this major difference, a minor difference was that the instrumentation used to monitor heart rate was the portable Exersentry Heart Rate Monitor (Model 3).

A conceptual departure from Kircher and Steinbeck involves terminology. As Trombly (1982, 1983) pointed out, simple exercise can be considered purposeful because it is a goal-oriented, voluntary behavior. It is possible that some individuals are more motivated (i.e., find more purpose) in simple exercise than in sports, games, or crafts. It is also possible that an individual might simultaneously pursue multiple goals and have multiple purposes. Therefore, in the terminology used in this study, adapted from Nelson (1984), jumping without a rope (JWOR) is "single-purpose" activity and jumping with a rope (JWR) is "added-purpose" activity.

This study goes beyond Kircher's design by including how subjects felt about the jumping activities. After participating, subjects were asked which activity they preferred. In addition, the affective meaning of each activity was assessed with Osgood's Semantic Differential (OSD), which Nelson, Thompson, and Moore (1982) demonstrated to be an effective measure of the affective meanings elicited by activities. Each of the three factors of the OSD (evaluation, power, and action) may reveal differences in subjects' experiences of different activities.
Evaluation is defined as the factor that summarizes the degree to which the person feels positively or negatively about something. Power is the factor of affective meaning that summarizes the person’s feelings in terms of the magnitude of effect something potentially has on its environment. Action is the factor of affective meaning that represents the person’s feelings about the degree of movement or volatility associated with something. (Nelson et al., 1982, p. 383)

In summary, six null hypotheses were tested: that there would be no significant difference between JWR and JWOR on each of the following dependent variables:

- pulse rate increase from baseline to cessation of jumping
- duration of jumping
- ratings on each of the three factors of the OSD
- activity preference

Method

Subjects. The subjects were 30 college women. The principal investigator obtained volunteers by asking students in physical education classes at a midwestern university if they wanted to participate in two jumping activities: jumping with a rope and jumping without a rope. Twenty-nine subjects were 18 to 23 years old and one was 31 years old. Their weights were from 104 to 145 lb, with a mean of 126 lb. Each subject read and then signed an informed consent form indicating that she did not have any heart, lung, orthopedic, or arthritic abnormality. The informed consent form also requested that the subject inform the researcher if she experienced any discomforting symptoms, such as dizziness, headache, shortness of breath, or undue fatigue, or if she wished to discontinue the experiment.

Instrumentation. The Exersentry Heart Rate Monitor (Model 3) measures the same electrical signal as the electrocardiogram. Three soft electrodes measure the “R” wave of the heart, its strongest electrical signal. The electrodes are permanently attached to a strap placed on the subject’s skin just below the pectoral muscles. The center of the electrode on the left side was placed 10¾ cm from the midline of the subject’s chest. The pair of electrodes on the right side were placed 10¾ cm and 12½ cm from the midline of the chest. The Exersentry recomputes the heart rate every four beats and displays it in a liquid crystal window that was not visible to the subjects. The reliability for the Exersentry is reported to be ±2 beats per minute over a possible recording range of 40 to 200 beats per minute (D. Peterson, Country Technology, Madison, WI, personal communication, November 5, 1986). According to the manufacturer’s manual (Computer Instruments Corporation, no date), the Exersentry was designed to be worn during strenuous exercise, such as jogging, aerobic dancing, and cross-country skiing. This heart rate monitor was used because it is more portable and more easily read than the instruments used by Kircher.

For safe maximum exertion, the subject’s individualized high target zone limit was determined and a standardized target zone formula (220 — age × 85%) was used to program this limit into the Exersentry for aerobic exercise (Wilson et al., 1981). The monitor sounded an alarm when the heart rate exceeded the subject’s maximum safe level. When the alarm sounded, the subject was asked to slow her jumping pace to lower the heart rate into the safe zone. The plan was to stop the experiment if the alarm continued for 30 seconds; however, this did not occur, and all subjects were able to complete the experiment.

The Borg Scale of Perceived Exertion (Borg, 1970) measures exertion on a scale of 6 to 20. Points on the scale range from very, very light (7) to very, very hard (19). Kircher (1984) used this scale as a guide for the subjects to decide when to stop jumping. The same procedure was used in this research. Skinner, Hutsler, Bergsteinova, and Buskirk (1973) determined the test–retest reliability of this scale to be \( r = .80 \) in a progressive test and \( r = .78 \) in a random test.

The short form of the OSD (Nelson et al., 1982) consists of 12 scales of paired bipolar adjectives. Scores range from 0 to 24 on each of the three factors of affective meaning. According to Kerlinger (1964), the OSD “has been shown to be sufficiently reliable and valid for many research purposes” (p. 579).

A questionnaire was used to determine each subject’s age and weight.

Procedure. After completing the demographic questionnaire, subjects were randomly assigned to Group A or Group B. Group A performed the JWR activity and then, after a minimum of 24 hours and before a maximum of 5 days, performed the JWOR exercise. Group B performed the same activities in the opposite order. This counterbalanced design, which controlled for a possible order effect, replicated Kircher’s procedure. Holding the testing sessions on two different days for each subject controlled for possible effects of fatigue.

At the beginning of each session, the experimenter calculated each subject’s target zone, programmed it into the Exersentry unit, and placed the monitor with electrodes on the subject and adjusted the straps. The liquid crystal window was positioned outward so that the subject could not view it. The subjects sat for 3 minutes prior to jumping. Heart rate was recorded before and after jumping, and monitoring continued after jumping at 30-second intervals for 2 minutes. A stopwatch was used to measure the length of time each subject jumped.
The same phrases and protocol reported by Kircher (1984, p. 167) were used. Before each jumping session, subjects were shown the Borg scale and were told, “jump until you feel that your body is working ‘very hard’—level 17 on the scale.” Then the activity was demonstrated. For JWR, the subjects were instructed to keep their arms down and close to their sides and to use wrist action to propel the rope. For JWOR, the subjects were instructed, “jump at a similar pace to jumping rope” and “jump high enough to clear a rope if you had one.” They were also told, “hold your arms as if you had a rope, but do not move your arms.”

After each jumping activity, subjects filled out the OSD. They were told

On this form there are 12 pairs of adjectives that you can use to describe how you felt about this jumping activity. For example, you can mark that it felt nice or awful. When you make each mark, you have seven choices. You can place it on the line separating the pair of adjectives in the middle or on either end depending on how you felt. Don’t mark on the little dots—mark between the dots. There are no right or wrong answers.

When the subjects had completed both jumping sessions and the second OSD scale, they were asked to write on the back of the OSD sheet which form of jumping they preferred and to explain why in a brief statement.

**Data Analysis.** Increase in heart rate was determined by subtracting resting heart rate from the heart rate recorded at the end of jumping. In a preliminary analysis, possible order effects between Group A and Group B were investigated through independent t tests. No order effects were found, so correlated t tests for paired comparisons were used to test for significant differences in heart rate, duration, and affective meaning between the two jumping activities.

**Results**

The increase in heart rate was significantly higher ($p = .01$) for JWR than for JWOR (see Table 1). A comparison of jumping duration between the two activities approached significance ($p = .06$), but in contrast to Kircher’s finding, in this study 20 of the 30 subjects jumped longer without a rope. This result should be interpreted with caution because the variance was not distributed equally across conditions.

However, even if the subject primarily responsible for this problem is removed as an outlier, the same pattern of results remains.

There were no significant differences on the three factors of affective meaning (evaluation: $p = .17$; power: $p = .67$; and action: $p = .28$) (see Table 2).

Sixteen of the subjects preferred jumping with a rope, 13 indicated a preference for jumping without a rope, and 1 had no preference. The likelihood of preferring JWR was not significantly greater than the likelihood of preferring JWOR. Reasons given for preferring jumping with a rope were that it was not boring or monotonous (5 subjects); the arms were being used (5 subjects); it involved more control, rhythm, or synchronization than the other activity (3 subjects); it was more purposeful (2 subjects); it involved the use of the mind (1 subject); and attention was diverted to the rope going around instead of your body getting tired (1 subject). The subjects who preferred jumping without a rope did so because it was easier (8 subjects); it did not require concentration (4 subjects); it was less frustrating (2 subjects), and it had no restrictions (1 subject).

**Discussion**

The significant increase in heart rate for JWR compared with JWOR supports Kircher’s finding. However, the mean duration of JWR in this study was 156 seconds versus the 188 seconds reported by Kircher, whereas the mean duration of JWOR in this study was 207 seconds versus Kircher’s 146 seconds. The duration data suggest that Kircher’s subjects exercised differently from subjects in the present study.

The most likely explanation for this apparent discrepancy is that this study had an imposed heart rate target zone for safe maximum exertion. During data collection, the Exersentry alarm (indicating safe max-

<table>
<thead>
<tr>
<th>Variable and Condition</th>
<th>M</th>
<th>SD</th>
<th>Range</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart rate increase (beats/min)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>With rope</td>
<td>96.17</td>
<td>18.14</td>
<td>39-120</td>
<td>2.72</td>
<td>.01</td>
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<tr>
<td>Without rope</td>
<td>82.50</td>
<td>20.14</td>
<td>31-119</td>
<td></td>
<td></td>
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<tr>
<td>Exercise duration (sec)</td>
<td></td>
<td></td>
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<tr>
<td>With rope</td>
<td>156.00</td>
<td>115.91</td>
<td>48-582</td>
<td>-1.92</td>
<td>.06</td>
</tr>
<tr>
<td>Without rope</td>
<td>206.60</td>
<td>211.41</td>
<td>60-1,200</td>
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</tbody>
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Note. $N = 30$, df = 29, tests are two-tailed.
imum exertion level) seemed to sound more frequently during the JWR activity than the JWOR activity. This subjective observation is consistent with the JWR heart rate data. Given that subjects had previously been told that the alarm indicated a high level of exercise, subjects may have been quicker to perceive themselves as working "very hard" on the Borg scale if they heard the alarm. Therefore, it is possible that subjects in the JWR condition in the present study would have continued to jump rope longer if there had been no alarm. In fact, several subjects later remarked that they normally exercised at a higher heart rate than the safe level used in this research.

Future research could confirm this explanation by manipulating the presence or absence of the alarm under the same experimental conditions. Perhaps verbal feedback from the researcher, with or without prior explanation of its meaning in terms of safety, would be perceived differently from the Exersentry's alarm. Also, future research could require subjects to perform to a lower level on the Borg scale, such as hard or somewhat hard. This choice depends on the strenuousness of the activity and the physical condition of the subjects. In addition, because jumping may well be affected by subjects' prior aerobic conditioning, treatments-by-levels experiments with level of conditioning as an independent variable may be fruitful.

Why was the heart rate increase greater in JWR than in JWOR? Steinbeck (1986) argued that the heart rate differences in Kircher's study indicated that the jumping activities were dissimilar in terms of workload. There may indeed be work load differences between the two jumping activities. Jumping with a rope adds upper extremity involvement and synchronization of the upper and lower extremities. Two other possible factors are the height of jumping and the rate of jumping; though subjects in the JWOR activity were instructed to jump at the same height and rate as if they were jumping rope, there was no way to ensure that they did. Ideally, future research will study heart rate while controlling for duration and will study duration while controlling for heart rate. However, the difficulty in doing so is well exemplified in Steinbeck's work (1986): Heart rate differences were statistically significant for a nonpurposeful compared with a purposeful pedaling activity and for a purposeful compared with a nonpurposeful squeezing activity. These differences, although in opposite directions, occurred even though heart rate was recorded as "to establish comparable levels of activity" (p. 531). One perspective on this is that methodological problems are inevitable in any new line of research and that both Kircher (1984) and Steinbeck (1986) are to be commended for helping to open a line of research of critical importance to the underlying roots of the profession despite methodological and conceptual uncertainties.

Despite uncertainty as to the specific motoric causes of the heart rate increase, the fact remains that subjects' perceptions of very hard on the Borg scale were influenced by the added purposes associated with jumping rope. Kircher's (1984) study, Steinbeck's (1986) study, and this study all support the proposition that persons engaged in added-purpose activity perceive a given level of exertion at a higher physiological level (in terms of heart rate) than persons engaged in single-purpose activity. On the one hand, the findings suggest the power of added-purpose activity to elicit positive physiological effects. On the other hand, as Kircher (1984) warned, cardiac patients may misperceive exertion level when they are involved in a purposeful activity.

The present study was unable to shed light on the affective factors involved in added-purpose activity. As always, a failure to reject the null hypothesis must be interpreted as an ambiguous finding, neither confirming nor denying differences between groups. Further research into the affective dimensions of added purposefulness in activities is highly recommended.

Conclusion

More research is needed to identify physiological and psychological effects of added purposefulness in activities. When interpreted in light of the clinician's theoretical frame of reference, this line of research may enable therapists to make more informed decisions when prescribing activity for clients who are at risk because of cardiovascular and other physically limiting conditions. This type of research may also support the selection of activities to motivate clients who are not at risk to work to a higher physiological capacity.

Acknowledgments

We thank Roger Zabik, PhD, chair of Health, Physical Education, and Recreation at Western Michigan University, for granting permission for this research to be conducted in conjunction with the physical education classes. This study was completed in partial fulfillment of the master of science degree in occupational therapy at Western Michigan University.

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