The Effects of Cadence, Impact, and Step on Physiological Responses to Aerobic Dance Exercise

Lynn A. Darby, Kathy D. Browder, and Brenda D. Reeves

The physiological responses to aerobic dance exercise of varied impact (high, low), step (less arm movement vs. more arm movement), and cadence (124 vs. 138 beats-min⁻¹) were investigated. Experienced, female aerobic dancers (N = 16) performed activities that combined the levels of impact and step for 3 trials of 8-min each. Dependent variables included heart rate, percentage of maximal heart rate, oxygen consumption, percentage of maximal oxygen consumption, and respiratory exchange ratio. Repeated measures analyses of variance indicated a significant Impact x Step interaction whereby oxygen consumption was greater for the high impact-less arm movement activity (jog), while the low impact-more arm movement activity (power jack) was greater for heart rate. The interaction of aerobic dance characteristics (e.g., impact, arm movement) that may affect physiological responses to aerobic dance exercise should be identified in future aerobic dance routines and studies.

Key words: aerobic dance exercise, high- and low-impact aerobic dance, cadence

Metabolic responses to high- and low-impact aerobic dance exercise have been reported previously by a number of investigators (Foster, 1975; Igbanugo & Gutin, 1978; Watterson, 1984; Weber, 1974; Williford, Scharff-Olson, & Blessing, 1989). Initially, the purpose of many studies was to determine if aerobic dance routines could be choreographed to elicit cardiorespiratory training effects. It is generally accepted that improvements in cardiorespiratory fitness can be elicited if the routines follow the guidelines for improving cardiorespiratory fitness (American College of Sports Medicine [ACSM], 1990; Cearly, Moffatt, & Knutzen, 1984; Watterson, 1984). After a high rate of injuries were reported for high-impact aerobic dance (Garrick & Regua, 1988; Koszuta, 1986), many instructors began designing low-impact activities in order to achieve cardiorespiratory benefits with reduced impact forces placed on the body. By definition, low-impact aerobic dance is exercise to music in which one foot remains in contact with the floor at all times. These routines typically involve less jumping and bouncing movements.

Similar metabolic responses to high- and low-impact aerobic dance exercise (i.e., oxygen consumption [VO₂] and heart rate [HR]) were reported by Reeves (1992; Reeves & Darby, 1991b), whereas Otto, Parker, Smith, Wygand, and Perez (1986) and Williford, Blessing, and Scharff (1988) reported different levels of VO₂ regardless of HR response to both impact levels. These apparent differences in metabolic responses may be attributed to impact. However, other factors (e.g., type of step, which may include extent and position of arm involvement, extent of lower body involvement, and cadence of the music) can also be altered to modify the step and, therefore, the intensity (i.e., HR and VO₂) of aerobic dance exercise. In a later study, Otto, Yoke, Wygand, and Larsen (1988) used "multidirectional," low-impact aerobic dance exercise and reported that comparable HR and VO₂ responses could be elicited using both impact levels. Arm involvement has not been described specifically in many of these previous studies.

Another important physiological result from previous studies that have compared impact levels is the relationship of HR to VO₂ or percentage of maximal heart rate (%HRmax) to percentage of maximal oxygen consumption (%VO₂max; both measures of the relative intensity of exercise) during aerobic dance exercise. Otto et al. (1986) and Stanforth, Hamman, and Senechal (1988) indicated that VO₂ and HR are not representative of the same exercise intensity. This has been supported more recently by Parker, Hurley, Hanlon, and Vaccaro (1989) who reported that when participants' HR responses to treadmill jogging and aerobic dance exercise were matched by intensity using

Submitted: May 31, 1994
Revision accepted: April 18, 1995

Lynn A. Darby and Kathy D. Browder are with the Kinesiology Division in the School of HPER at Bowling Green State University, Ohio. Brenda D. Reeves is with the Department of Health Promotion and Human Performance at the University of Toledo, Ohio.
VO\textsubscript{2}, HR responses were 10% greater during the aerobic dance exercise. However, Berry, Cline, Berry, and Davis (1992) did not support the findings of Parker et al. and reported no difference in HR and VO\textsubscript{2} responses between aerobic dance exercise with arms above and arms below the shoulders and treadmill running. In the arms above the shoulders condition, participants completed 15 min of exercise using the arms dynamically. Berry et al. speculated that the differences in the results from the two studies were possibly due to differences in the fitness level of the participants and the lower exercise intensity (%VO\textsubscript{2max}) at which the participants of their study exercised. Stanforth et al. reported differences in the %VO\textsubscript{2max} and HR relationship for low-impact aerobic movements with minimal lower body involvement.

These factors (e.g., step, cadence, fitness level, impact) that may cause inconsistencies in study results on physiological responses to aerobic dance exercise need to be clarified. Thus, the purpose of the present study was to assess the effects of aerobic dance exercise varied by impact, step (arm movement), and cadence on the physiological responses of aerobic dancers. It was hypothesized that activities that consist of high impact, more arm movement, and higher cadence would elicit greater physiological responses.

**Method**

**Participants**

Females (N = 16; M age = 23.0 ± 3.7 years) with previous aerobic dance exercise instructional experience were recruited for the study. Previous aerobic dance exercise instructional experience was defined as having taught aerobic dance classes. In addition, all participants reported that they engaged in aerobic dance exercise weekly (i.e., three to five times per week). All participants were classified as apparently healthy according to the ACSM guidelines (ACSM, 1991).

**Design**

A 2 x 2 x 2 x 3 (Cadence x Impact x Step x Trial) repeated measures design was employed in the present study. The levels of cadence were 124 and 138 beats-min\textsuperscript{-1}, high- and low-impact levels were observed, and more and less arm movement was defined as the levels of step, and trial levels included 8-min periods in which each participant completed the various aerobic dance exercise combinations (cadence, impact, step) for 1-min each. One-minute data collections were utilized to simulate a typical aerobic dance exercise workout. Three trials were completed.

The levels of impact and step could be combined by using four common aerobic activities: jumping jack, power jack, jog, and march. The high impact-more arm movement condition was represented by the jumping jack, the high impact-less arm movement condition by the jog, the low impact-more arm movement condition by the power jack, and the low impact-less arm movement condition by the march. Each of these four activities were performed at the two levels of cadence for 1-min each to produce 8 min of aerobic dance exercise. The dependent variables were absolute VO\textsubscript{2}, relative VO\textsubscript{2}, %VO\textsubscript{2max}, HR, %HRmax, gross and net energy costs, and respiratory exchange ratio (RER).

**Description of Aerobic Dance Activities**

These conditions were chosen to isolate the effects of step, impact, and cadence based on previously reported information by Reeves (1992) and Reeves, Darby, Moss, and Armstrong (1992), who compared a number of aerobic dance exercise activities for metabolic responses and impact forces. For the present study, conditions were chosen that are commonly completed in aerobic dance exercise routines and that are easily replicated by the participants.

The four levels of impact and step previously identified (jog, march, jumping jack, and power jack) were selected based on impact and arm involvement (determined by shoulder range of motion [ROM] and position relative to heart level). The jog is a high-impact activity in which there is an airborne phase, and shoulder ROM is 0° while arms are kept below heart level. The march is similar to the jog in its movement pattern, but one foot remains in contact with the ground, which is consistent with the definition of low-impact aerobic dance exercise. Shoulder ROM is relatively small: approximately 30° of flexion and 30° of hyperextension.

The jumping jack and power jack have more arm involvement in that the arms reach heart level or higher during the activity and thus greater shoulder ROM is performed. During the jumping jack, the arms and legs are simultaneously abducted 90° and 30°, respectively. The power jack is performed by isometrically holding the arms in 90° of abduction and horizontally flexing and extending these through 120°. The legs are abducted and adducted at the same time the arms are horizontally extended and flexed, respectively. Consistent with previous definitions, the jumping jack is classified as a high-impact condition, and the power jack is a low-impact condition.

**Instrumentation**

Metabolic data for the study (VO\textsubscript{2}, %VO\textsubscript{2max}, gross and net energy costs, and RER) were measured using a Sensormedics 2900 metabolic measurement cart.
(Sensormedics, Yorba Linda, CA). The metabolic cart was calibrated with medical gases of certified concentrations and a calibrated (3 L) syringe. Each participant was connected to the metabolic cart via a Hans-Rudolph two-way nonrebreathing large T-shaped valve (Model No. 2700, Hans-Rudolph, Inc., Kansas City, MO) and respiratory tubing. Metabolic data were collected every 20 s during exercise, and minute averages for all variables were calculated postexercise.

Heart rate data were measured using a Polar Vantage XL Heart Rate Monitor (Polar USA, Inc., Stamford, CT), with HR data collected every 30 s throughout the dance routine data collection. A similar heart watch has been shown to measure HR comparable to measures taken from the electrocardiogram (EKG; Kline et al., 1987). Minute averages were calculated postexercise, and %HRmax was determined using HRmax measured during a maximal graded treadmill test.

For the maximal graded exercise test, HR and EKGS were monitored using a Quinton 4000 Electrocardiograph (Quinton Instruments Co., Seattle, WA). EKGS were printed each minute and evaluated to monitor the participants’ responses during the graded exercise test.

Procedure

Each participant completed two testing sessions: dance routine and maximal graded exercise test. Prior to participation in the study, each participant completed a medical history questionnaire and an informed consent statement.

Dance routine. For the data collection during the dance routine, each condition (i.e., jog, march, jumping jack, or power jack) was completed for 1 min at two cadences in order to simulate a typical aerobic dance workout. The participant’s expired air was transported via respiratory tubing to the metabolic cart. The tubing was supported by a test administrator and held medial and posterior to the participant so that arm movements could be completed. After resting data were collected in a sitting position for 2 min, 3 min of aerobic dance exercise warm-up was completed by each participant. After warm-up, each participant completed three, 8-min trials successively for a total of 24 min of continuous exercise. Each participant followed the lead of an aerobic dance leader in order to simulate a typical aerobic dance routine and to have all participants complete the dance routine similarly.

Maximal graded exercise test. At a separate testing session to determine VO2 max, each participant completed a maximal graded exercise test on the treadmill. Metabolic data and EKG data were collected. The treadmill protocol consisted of a warm-up for 3 min at a speed and grade of 3.0 mph and 0%, respectively. Then speed and grade were increased by 1.0 mph and by 2% grade, respectively, at the end of each 2-min stage. The test was terminated when the participant met the criteria for VO2 max. Criteria used for the attainment of VO2 max were volitional exhaustion, RER > 1.0, HR in excess of 190 beats-min⁻¹, or failure of VO2 to increase with increasing workloads (Fox & Mathews, 1981; Taylor, Buskirk, & Henschel, 1955). Thus, VO2 max was defined as the greatest minute value obtained during the treadmill test. At this testing session, body composition was also determined using the skinfold caliper method of Jackson, Pollock, and Ward (1980).

Results

Reliability of Measures

Typically 2- or 3-min data collections are utilized when determining the energy cost of activities. However, in the present study, data were collected for only 1 min because the objective was to simulate a typical aerobic dance workout. During pilot data collection, differences for VO2 among the conditions were determined to be small and, for the present study, were approximately 300 ml, ranging from 1,760 ml-min⁻¹ to 2,060 ml-min⁻¹. This leveling of VO2 at a new level when a different step was performed occurred within 20 s. Intraclass correlation coefficients for VO2 for all levels of impact and step from Trials 2 and 3 ranged from .73 to .99.

Descriptive Statistics

Demographic data for the participants are presented in Table 1. The mean VO2 max of the participants would rank these participants as high (trained) according to the American Heart Association norms for VO2 max in female adults 20-29 years of age (American Heart Association, 1972). Prior to participation in the present study, participants reported previous aerobic dance instructional experience (i.e., having taught aerobic dance exercise classes). All participants practiced the four aerobic dance activities until they per-

Table 1. Demographic data for the participants (N = 16)

<table>
<thead>
<tr>
<th>Variable</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>23.0</td>
<td>3.7</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>162.2</td>
<td>6.5</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>58.1</td>
<td>5.8</td>
</tr>
<tr>
<td>Body fat (%)</td>
<td>22.6</td>
<td>3.1</td>
</tr>
<tr>
<td>HRmax (b-min⁻¹)</td>
<td>190.0</td>
<td>7.9</td>
</tr>
<tr>
<td>VO2 max (ml·kg⁻¹·min⁻¹)</td>
<td>49.6</td>
<td>3.5</td>
</tr>
</tbody>
</table>

Note. HRmax = maximal heart rate; VO2 max = maximal oxygen consumption.
formed the activities in accordance with the description for each activity.

Eight dependent variables were assessed in the present study. A correlation matrix for the eight dependent variables for all trials are presented in Table 2. There were high correlations (r > .70) among many of the physiological variables (see Table 2). Therefore, for subsequent analyses, redundant variables were eliminated and three main physiological measures were assessed: HR, relative VO₂, and RER.

Physiological Responses

A 2 x 2 x 2 x 3 (Cadence x Impact x Step x Trial) repeated measures analysis of variance was calculated for each of the three dependent variables retained for analysis. Because the chance of increasing the experimentwise Type I error is increased when performing a number of simultaneous tests of hypotheses (i.e., multiple analyses on the same participants for the same conditions), the alpha level (p < .017) was adjusted using the Bonferroni technique (Beal & Khamis, 1991).

When a significant F ratio was found, a Tukey HSD post hoc test (p < .05) was used to examine which means differed. In addition, the effect size for each dependent variable was calculated using partial eta squared which is an indication of the proportion of the variance accounted for by the independent variables (Stevens, 1990; Thomas, Salazar, & Landers, 1991). Partial eta squared provided information on how effective each combination of impact and step was for producing significant physiological differences.

HR: A significant Impact x Step interaction was obtained for HR, F (1, 15) = 82.3, p < .0001. The low impact-more arm movement condition (power jack) was significantly greater than the other three conditions. The low impact-less arm movement condition (march) recorded significantly lower HR than the other conditions (see Table 3). For HR, partial eta squared was .87, indicating a strong effect (Thomas et al., 1991).

VO₂: A significant Impact x Step interaction was obtained for relative VO₂, F (1, 15) = 184.0, p < .0001. The high impact-less arm movement condition (jog) was greater than all other conditions (see Table 3). The low

<table>
<thead>
<tr>
<th>Table 2. Correlation matrix for all dependent variables (N = 384)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable</td>
</tr>
<tr>
<td>---------</td>
</tr>
<tr>
<td>HR</td>
</tr>
<tr>
<td>Absolute VO₂(L·min⁻¹)</td>
</tr>
<tr>
<td>Relative VO₂(ml·kg⁻¹·min⁻¹)</td>
</tr>
<tr>
<td>%VO₂max</td>
</tr>
<tr>
<td>%HRmax</td>
</tr>
<tr>
<td>Gross energy cost(kcal·min⁻¹)</td>
</tr>
<tr>
<td>Net energy cost(kcal·min⁻¹)</td>
</tr>
</tbody>
</table>

Note. VO₂ = oxygen consumption; %VO₂max = percentage of maximal oxygen consumption; HR = heart rate; %HRmax = percentage of maximal heart rate; RER = respiratory exchange ratio.
* p < .0001.

<table>
<thead>
<tr>
<th>Table 3. Means and standard deviations by condition for all trials</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable</td>
</tr>
<tr>
<td>---------</td>
</tr>
<tr>
<td>VO₂(L·min⁻¹)</td>
</tr>
<tr>
<td>VO₂(ml·kg⁻¹·min⁻¹)</td>
</tr>
<tr>
<td>%VO₂max</td>
</tr>
<tr>
<td>HR(b·min⁻¹)</td>
</tr>
<tr>
<td>%HRmax</td>
</tr>
<tr>
<td>Gross energy cost(kcal·min⁻¹)</td>
</tr>
<tr>
<td>Net energy cost(kcal·min⁻¹)</td>
</tr>
<tr>
<td>RER</td>
</tr>
</tbody>
</table>

Note. VO₂ = oxygen consumption; %VO₂max = percentage of maximal oxygen consumption; HR = heart rate; %HRmax = percentage of maximal heart rate; RER = respiratory exchange ratio.
* n = 98.
* n = 95.
impact-less arm movement condition (march) was significantly less than all other conditions. For VO\textsubscript{2} partial eta squared was .92, indicating a strong effect.

RER. Unlike the other dependent variables, no significant Impact x Step interaction was found for RER, $F(1, 15) = 5.4, p < .04$, nor were any main effects present for RER (see Table 3).

Discussion

Conflicting results that have been reported in the literature concerning metabolic responses to aerobic dance exercise may be due to the interaction between the effects of impact and arm movement. In the present study, the low impact-more arm movement condition (power jack) was greater than all other conditions for HR, whereas the high impact-less arm movement condition (jog) was significantly greater than the other conditions for VO\textsubscript{2}. Although the differences among the means were small, these differences were statistically significant due to the high power of the within-subjects design and the homogeneity of the group studied. Theoretically, the results may be used for delineation of factors that affect HR and VO\textsubscript{2}, whereas practically (i.e., in an actual aerobic dance session) small changes in HR and VO\textsubscript{2} may not affect the outcome or intent of the aerobic dance (e.g., improvement in fitness level). Even though the magnitude of the changes may not be great for HR and VO\textsubscript{2}, the fact that HR and VO\textsubscript{2} do not necessarily change similarly for each condition may be important.

Similar results for HR have been reported by Carroll, Otto, and Wygand (1991) and by Astrand, Guharay, and Wahren (1968) for arm work performed above the head when compared to arm work performed below head level. However, the high impact-more arm movement condition (jumping jack) in the present study did not show similar HR/VO\textsubscript{2} changes. This difference between the jumping jack and power jack may be explained by the difference in the type of arm exercise performed; that is, static versus dynamic.

In the present study, the low impact-more arm movement condition (power jack) involved holding the arms at shoulder level and performing horizontal shoulder flexion and extension in time with the leg action of lunging to either side. During the power jack, the increase in HR without similar increases in VO\textsubscript{2} would be comparable to the pressor response reported during rhythmic leg exercise performed while isometrically carrying weights (Lind & McNichol, 1967, 1968). The large isometric component of the arms during the power jack increases HR. This is in agreement with Carroll et al. (1991) who studied the combined effects of arm position and handheld weights and reported a significantly greater HR for low-impact aerobics above shoulder level with weights when compared to below shoulder level without weights and below shoulder level with weights. Carroll et al. also reported no significant differences for VO\textsubscript{2} for the various arm positions during low-impact aerobics.

Previous studies (Parker et al., 1989), which have also noted this difference in HR and VO\textsubscript{2} responses to aerobic dance activities, have recommended that care be taken when interpreting %HR\textsubscript{max} and when assuming it is representative of %VO\textsubscript{2max}. During many types of aerobic exercise (e.g., cycling, jogging), intensity is regulated at a %HR\textsubscript{max} or a %VO\textsubscript{2max}. Participants in the present study were working at approximately 85% of HR\textsubscript{max} and 70% of VO\textsubscript{2max} for all steps except the march (see Table 3). Results from the present study would support previous reports (Hufnand, Crowe, Whaley, & Banning-Schaffner, 1988) which directly or indirectly suggest that aerobic dance participants desiring to increase the intensity of exercise to increase fitness levels should include whole body exercise that increases VO\textsubscript{2} and not exercises of smaller muscle groups that increase HR without corresponding increases in VO\textsubscript{2}. Many exercisers are not aware of the relationships between HR and VO\textsubscript{2} and between %HR\textsubscript{max} and %VO\textsubscript{2max}. This may have some aerobic dancers believing they are working harder and expending more calories than they actually are. Aerobic dance activities can be choreographed to elicit specific metabolic responses (Reeves & Darby, 1992). Reeves and Darby (1991a) constructed a dance exercise test in which aerobic dance activities were systematically organized to provide progressive increases in HR and VO\textsubscript{2} similar to a graded exercise treadmill test.

Other factors that should be considered in interpretation of the %HR\textsubscript{max} and %VO\textsubscript{2max} relationship are the fitness level and aerobic dance exercise skill of the participants. Cardiorespiratory fitness will directly affect the participants’ ability to complete and sustain the selected aerobic dance exercise activities because some choreographed activities may be too strenuous for less fit individuals. When compared to aerobic dancers in previous investigations, VO\textsubscript{2max} of the participants in the present study were approximately the same as participants studied by Berry et al. (1992) and greater than those of Parker et al. (1989) and Claremont, Simowitz, Boarman, Asbell, and Auferoth (1986). In the present study, participants easily completed all trials, and fatigue did not significantly affect the physiological responses. If the participants are not skilled at performing specific aerobic dance activities, then more energy may be expended than if these activities were performed in a coordinated manner. The level of metabolic and HR responses to the exercise in the present study would be classified as medium or high intensity as compared to data from Claremont et al.
Finally, a better description of the activities and choreography used in aerobic dance exercise studies is needed so that comparisons can be made among studies. Williford et al. (1989) attributed the conflicting results in metabolic responses to high- and low-impact aerobic dance exercise to “stylistic requirements” and poorly prescribed standards for differentiating high-versus low-impact aerobic dance exercise. Berry et al. (1992) also indicated that comparisons among studies of aerobic dance are difficult because of the components which may make up the routines (i.e., static, dynamic, combination of static and dynamic components). The authors of the present study would support this statement in that criteria are minimal and that aerobic dance exercise activities have been vaguely defined in the Method sections of most papers studying metabolic responses. However, Williford et al. (1989) also stated that standards of aerobic dance exercise may not be possible due to the inherent “artistic quality” of aerobic dance exercise.

Due to discrepancies in the aerobic dance exercise literature, future studies should use some type of movement analysis (see Table 4) to completely and adequately supply needed information concerning arm movement, level of arm involvement (i.e., above or below heart level), cadence, type of muscular contraction (static or dynamic), movement position, and ROM. A detailed description of the steps involved to produce the metabolic responses should be provided in the Method section. Also, the small but statistically significant changes in HR and \( \text{VO}_2 \) for this study need to be further examined, particularly in untrained or less homogeneous groups. Although the practical significance of these results may differ from the theoretical significance, the results indicate that future studies should carefully examine factors affecting the HR and \( \text{VO}_2 \) relationship.

Certain instructors may be interested in the \( \text{VO}_2/\text{HR} \) relationship and responses that can be elicited for each exerciser. It has been previously reported that aerobic dance exercise instructors could only choreograph routines of low and high intensity (Claremont et al., 1986). Routines intended to be choreographed at a medium intensity evoked physiological responses equal to the high-intensity routines. Knowledge of factors that influence HR and \( \text{VO}_2 \) responses to exercise may help these instructors to better prescribe and individualize exercise programs. In addition, provision of these details will make future comparisons among studies and interpretations of metabolic responses to aerobic dance exercise more complete.

## References


### Table 4. Movement analysis of aerobic dance steps performed at cadences of 124 and 138 b·min⁻¹

<table>
<thead>
<tr>
<th>Step/Impact</th>
<th>Arm level</th>
<th>Joint</th>
<th>Type of muscular contraction</th>
<th>Movement/Position</th>
<th>Range of motion (^a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jog/High</td>
<td>Below(^b)</td>
<td>Shoulder</td>
<td>Isometric</td>
<td>Neutral</td>
<td>( @0^\circ )</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Elbow</td>
<td>Dynamic</td>
<td>Flexion</td>
<td>0–130(^\circ)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hip</td>
<td>Dynamic</td>
<td>Flexion</td>
<td>0–30(^\circ)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Knee</td>
<td>Dynamic</td>
<td>Flexion</td>
<td>0–30(^\circ) (support)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ankle</td>
<td>Dynamic</td>
<td>Flexion</td>
<td>0–30(^\circ) (airborne)</td>
</tr>
<tr>
<td></td>
<td>Above(^c)</td>
<td>Shoulder</td>
<td>Isometric</td>
<td>Abduction</td>
<td>( @90^\circ )</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Shoulder</td>
<td>Dynamic</td>
<td>Horizontal flexion</td>
<td>0–120(^\circ)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Elbow</td>
<td>Isometric</td>
<td>Flexion</td>
<td>( @90^\circ )</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hip</td>
<td>Dynamic</td>
<td>Flexion</td>
<td>0–90(^\circ)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Knee</td>
<td>Dynamic</td>
<td>Flexion</td>
<td>0–90(^\circ)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ankle</td>
<td>Dynamic</td>
<td>Extension</td>
<td>0–30(^\circ)</td>
</tr>
</tbody>
</table>

\(^a\)Anatomical position is considered 0\(^\circ\).
\(^b\)Below indicates below heart level.
\(^c\)Above indicates above heart level.


Authors' Notes

The authors would like to acknowledge Scott Chamberlain, Darlene Day-Herzog, and graduate and undergraduate students in the School of Health, Physical Education, and Recreation at Bowling Green State University for their assistance in data collection. Correspondence concerning this article should be addressed to Lynn A. Darby, PhD, Kinesiology Division, School of Health, Physical Education, and Recreation, 215 Eppler South, Bowling Green State University, Bowling Green, OH 43403.

E-mail: ldarby@bgnet.bgsu.edu