DEVELOPING A COMPREHENSIVE EXERCISE PRESCRIPTION: THE OPTIMAL ORDER FOR CARDIORESPIRATORY, RESISTANCE, FLEXIBILITY, AND NEUROMOTOR EXERCISE

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ABSTRACT

Introduction: Exercise professionals can follow readily available published guidelines, provided from major health organisations, when designing comprehensive exercise programs consisting of cardiorespiratory, resistance, flexibility, and neuromotor exercise. Paradoxically, when combining these types of exercise into the same exercise session, there are no current recommendations for the most appropriate exercise order. The purpose of this study was to provide preliminary evidence for establishing an optimal exercise order of cardiorespiratory, resistance, flexibility, and neuromotor exercise.

Methods: A total of 20 participants performed an exercise prescription (ExRx) consisting of all possible sequences (24 combinations) of cardiorespiratory, resistance, flexibility, and neuromotor exercise. Physiological and psychological responses to exercise were measured throughout each exercise session. Repeated-measures ANOVA and polynomial trend analysis were performed to determine if physiological and psychological responses to exercise differed according to exercise order.

Results: The mean heart rate (HR) response to cardiorespiratory exercise was significantly different (p<0.05) across all exercise sequence positions. When cardiorespiratory exercise was performed first the HR response equated to 56% heart rate reserve (i.e., moderate-intensity exercise). In contrast, the mean HR response equated to 66.7% heart rate reserve (i.e., vigorous-intensity exercise) when cardiorespiratory exercise was sequenced last in the exercise session. Mean resistance exercise rating of perceived exertion (RPE) was similar (p>0.05) when resistance exercise was positioned either first or second in the ExRx; however, post hoc tests showed mean resistance exercise RPE was significantly higher (p<0.05) when the...
INTRODUCTION

Chronic diseases are the major cause of death and disability both within the United States and worldwide. Diseases such as cardiovascular diseases (including hypertension and stroke), type 2 diabetes, obesity, respiratory disease and some forms of cancer have become so prevalent in today’s society that the occurrence is considered an epidemic. Biomedical actions have been taken against chronic disease but have been unsuccessful in reversing this epidemic. Medicinal treatments function as secondary or tertiary prevention, meaning they are prescribed after an event or disease occurs. The continuing upward trend of chronic disease that occurs with biomedical treatments reinforces the need for primary prevention through physical activity. Regular physical activity shows considerable promise as a primary preventative strategy. Strong evidence from prospective cohort studies and randomised controlled trials have shown a strong inverse dose response relationship between physical activity and reduced risk of all-cause mortality and other cardiometabolic health outcomes. Exercise beyond daily activity is often essential for improving and maintaining the physical fitness and health of adults. Exercise is beneficial in several ways: it has been shown to reduce the risk of all-cause mortality and morbidity and to promote psychological health. Exercise functions to decrease mortality and morbidity by preventing and eliminating the risk factors of chronic disease through improvements in cardiovascular and metabolic health.

Cardiorespiratory, resistance, flexibility, and neuromotor exercise are the four main types of exercise that promote physical fitness. Cardiorespiratory exercise is the most effective way to improve an individual’s cardiorespiratory fitness and blood lipid profile. Low cardiorespiratory fitness is considered a risk factor for chronic disease, morbidity, and all-cause mortality. Increasing cardiorespiratory fitness eliminates this risk factor and helps prevent the development of chronic diseases. Cardiorespiratory training improves the blood lipid profile by increasing concentrations of high density lipoproteins, lowering the concentrations of low density lipoproteins and triglycerides, and increasing lipoprotein particle size. In addition, an increase in caloric expenditure promotes weight loss when the amount of calories expended exceeds the amount consumed. Resistance training functions primarily to improve muscular strength and secondarily to improve body composition, blood lipid profile, blood pressure and insulin sensitivity. These factors are all related to metabolic syndrome and heart disease, so an improvement in these factor profiles can prevent chronic diseases. Resistance training can also reduce the risk of developing musculoskeletal disorders by promoting muscle strength. Flexibility training through

Conclusion: Results of this novel study provide important preliminary evidence towards formulating recommendations for an optimal sequence of cardiorespiratory, resistance, flexibility and neuromotor exercise for the ExRx. Findings from the present study suggest cardiorespiratory exercise should always be performed first followed next by resistance exercise. Flexibility and neuromotor exercise can be positioned at a later point in the ExRx.

Keywords: exercise program, health and fitness, physical activity, primary prevention

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stretching can improve postural stability, balance, and joint range of motion\(^5\). A muscle that is stretched experiences an increase in flexibility and a temporary decrease in muscle power output\(^3,5\). Neuromotor training promotes neuromotor function by improving balance, agility, muscle strength, and proprioception; these areas are improved by incorporating motor skills into different activities that challenge them\(^9\).

The current American College of Sports Medicine (ACSM) recommendations focus on the frequency, intensity and duration of the four exercise types mentioned above (cardiorespiratory, resistance, flexibility, and neuromotor)\(^6,9\). The cardiorespiratory exercise recommendation for moderate intensity training is 30 minutes a day, five days a week and 20 minutes a day, three days a week for vigorous-intensity training. The recommendations for neuromotor, resistance and flexibility training are to perform each mode two to three days a week\(^6,9\). Adherence to these recommendations ensures that the individual training fulfills the maximum frequency requirements for each form of exercise to gain optimal health benefits; however, to fulfill these maximum frequency requirements (14 overall – 5 aerobic sessions, 3 flexibility sessions, 3 neuromotor sessions, and 3 resistance sessions), individuals have to perform two or more of the exercise types in the same day. For individuals with limited time, the exercises may have to be performed not only within the same day, but within the same session. Although the ideal frequency, intensity and duration are known for each exercise mode individually, the sequence in which to perform the exercises in one program (concurrent training for example) for the highest benefits is still unclear.

Concurrent training is primarily focused on the combination of cardiorespiratory and resistance training in one exercise session, but in order to meet ACSM recommendations, neuromotor and flexibility exercises must also be incorporated. The incorporation of all four types of exercise into one program may be a common occurrence for individuals trying to save time. However, when performing two exercises sequentially, the benefits of one may be altered. For example, when resistance training directly follows aerobic exercise, the strength training may be negatively impacted. Indeed, previous research has reported that there is reduced strength training performance in the muscle groups that were fatigued during aerobic exercise\(^14\). This same study also found that the volume of work that can be done by the localised muscle groups can be diminished for up to eight hours after aerobic training\(^14\). In contrast, some studies have shown that concurrent training can result in positive adaptations. For instance, it has been found that concurrent training can be effective in improving muscle strength, body composition, aerobic power and muscular endurance\(^15\). Cardiovascular and cardiorespiratory adaptations have also been observed as a result of concurrent training\(^16\).

To our knowledge, there is currently no evidence for an appropriate exercise order when cardiorespiratory, resistance, neuromotor, and flexibility exercise are combined within a single exercise session. Therefore, the purpose of this study was to provide preliminary data for establishing an optimal exercise order of cardiorespiratory, resistance, flexibility, and neuromotor exercise.

**METHODS**

**Participants**

A convenience sample of 24 healthy men and women between 18 to 39 years of age were recruited from University students and faculty and the surrounding local community to participate in the present study. To minimise change of fitness as a potential confounder we recruited participants whom were currently active and had previous experience with all types of training. This study was approved by the Human Research Committee at Western State Colorado University. Prior to participation, each participant signed an informed consent form and underwent baseline testing.
Baseline testing

The measures acquired from baseline testing were used to establish an individualised exercise prescription (ExRx). Baseline testing consisted of a maximal exercise test to determine maximal oxygen uptake. Additionally, one repetition maximum (1-RM) testing for eight resistance training exercises was performed. Last, a sit-and-reach test, 5-10-5 shuttle run, hexagonal agility test, and single leg half squats on each leg were completed to familiarise participants with the flexibility and neuromotor exercises.

Maximal exercise testing

Participants were instructed to sit quietly in a chair for five minutes. The lowest measured heart rate (HR) between the fourth and fifth minute of rest was recorded as the resting HR. Participants then completed a modified-Balke, pseudo-ramp graded exercise test (GXT) on a power treadmill (Powerjog GX200, Maine). Participants ran at a self-selected pace. Treadmill incline was increased by 1% every minute until the participant reached volitional fatigue. Participant HR was continuously recorded during the GXT via a chest strap and radio-telemetric receiver (Polar Electro, Woodbury, NY, USA). Expired air and gas exchange data were recorded continuously during the GXT using a metabolic analyser (Parvo Medics TrueOne 2.0, Salt Lake City, UT, USA). Before each exercise test, the metabolic analyser was calibrated with gases of known concentrations (14.01 ± 0.07% O$_2$, 6.00 ± 0.03% CO$_2$) and with room air (20.93%O$_2$ and 0.03% CO$_2$) as per the instruction manual. Volume calibration of the pneumotachometer was done via a 3-Litre calibration syringe system (Hans-Rudolph, Kansas City, MO, USA). The last 15s of the GXT were averaged – this was considered the final data point. The closest neighbouring data point was calculated by averaging the data collected 15s immediately before the last 15s of the test. The mean of the two processed data points represented VO$_{2\text{max}}$. Maximal HR was considered to be the highest recorded HR during the GXT. Participant heart rate reserve (HRR) was determined by taking the difference between maximal HR and resting HR.

1-RM testing

Participants performed 1-RM testing for eight separate resistance exercises. The following protocol was used for all 1-RM testing:

1. 10 repetitions of a weight the participant felt comfortable lifting (40-60% 1-RM) were performed to warm up muscles
2. RPE was recorded followed by 1 minute rest period
3. 5 repetitions of weight 60-80% 1-RM was performed as a further warm up, RPE recorded followed by a 2 minute rest period
4. First 1-RM attempt at weight of 2.5-20kg greater then warm up, weight was dependent on RPE of warm up
   a. If first 1-RM lift was deemed successful by the researcher (appropriate lifting form) weight was increased until maximum weight participant can lift was established with 3 minutes between each attempt.
   b. If first 1-RM lift deemed unsuccessful by the researcher, weight was decreased until participant successfully lifted the heaviest weight possible

There were 3 minutes rest between 1-RM attempts and a maximum of 5 1-RM attempts. There were 5 minutes of rest between the 1-RM testing of each resistance exercise.

Exercise sessions

After baseline testing, participants performed an ExRx that consisted of 24 standardised exercise sessions adhering to current ACSM ExRx guidelines for cardiorespiratory, resistance, flexibility, and neuromotor exercise. The exercise sessions were performed in all possible sequences using the counterbalanced experimental design displayed in Figure 1. Each training session was separated by a minimum of 48 hours and no more than 7 days. All exercise sessions were directly supervised by a member of the research team.
Cardiorespiratory exercise

The cardiorespiratory exercise component of the ExRx consisted of 30 minutes of treadmill exercise. For cardiorespiratory exercise, participants started with a five minute 5.6 kmh warm up at 0% incline. After the warm up, treadmill speed was gradually titrated over the first five minutes to elicit a moderate-intensity (50-60% HRR) heart rate response. Participants maintained this treadmill workload for a total 20 minutes. After 20 minutes participants then cooled down for five minutes at 5.6 kmh. Exercise HR was recorded at five minute intervals throughout the cardiorespiratory exercise session. The overall mean HR from these recorded values was used for data analysis. The same treadmill workload was subsequently used for all exercise sessions.

Resistance exercise

The resistance exercise component of the ExRx consisted of eight different resistance exercises: bench press, lateral pull downs, tricep pull downs, bicep curls, squats, knee extension, knee flexion, and calf raises. Participants performed 2 sets of 12 repetitions for each exercise at a resistance equating to 60% 1-RM. This resistance exercise ExRx aligns with current ACSM ExRx guidelines for which there is Category A evidence. There were 1-minute rest periods between each exercise and a 2-minute rest period between sets. At the conclusion of the resistance exercise component participants were asked to provide a session rating of perceived exertion (RPE) as described elsewhere.

Flexibility exercise

The flexibility exercise component of the ExRx consisted of eight different flexibility exercises. The flexibility exercises included lying gluteal stretch, standing quadriceps stretch, hip flexor stretch, lying hamstring stretch, standing calf stretch, chest stretch, triceps stretch and shoulder stretch. Each stretch was performed on both sides of the body. Participants were instructed to perform all stretches to a point of mild discomfort. Each stretch was held for a duration of 20 seconds. Participants completed 2 sets of each flexibility exercise. At the conclusion of the flexibility exercise component of each of the 24 standardised exercise sessions participants performed the sit-and-reach test. The protocol for the sit-and-reach test is described in detail elsewhere. The sit-and-reach test was performed three times with one minute rest between each trial. The average of all three trials was used in data analysis.
Neuromotor exercise

The neuromotor exercise component of the ExRx consisted of three different exercises: the 5-10-5 shuttle run, the hexagonal agility test, and single leg squat test (a measure of dynamic balance). The neuromotor exercise component of the ExRx was sequenced according to the counterbalanced experimental design displayed in Figure 1. However, the order of neuromotor exercises within each neuromotor exercise component was kept consistent. Participants performed each of the three neuromotor exercises with 90 seconds rest between each exercise. Participants then completed a second set of each neuromotor exercise with 90 seconds rest between exercises. The mean of the two trials for each neuromotor exercise was recorded.

5-10-5 shuttle run

The 5-10-5 shuttle run was set up by placing three cones five yards apart. The participant initiated the protocol when the tester indicated, and sprinted from the centre cone to the left side cone, turned, sprinted to the furthest right cone, turned and sprinted back to the centre cone\(^\text{17}\). The 5-10-5 shuttle run was timed by a researcher.

Single leg squat test

Participants were instructed to stand on one leg while the other leg was lifted off the ground in front of the body so that the hip was flexed to approximately 45\(^\circ\) and the knee of the non-stance leg flexed to approximately 90\(^\circ\). Participants were also instructed to hold arms straight out in front, with the hands clasped together. From this starting position, participants were instructed to squat down until about 60\(^\circ\) knee flexion, then return to the start position\(^\text{18}\). Participants completed as many repetitions as possible. The exercise was completed on both legs. The overall number of repetitions performed by participants were recorded by a researcher.

Hexagonal test

The hexagonal test was set up with cones two feet apart with an angle of 120\(^\circ\). The participant commenced the protocol when the tester indicated. The participant started in the centre of the hexagon and jumped to each corner, returning to the centre each time\(^\text{18}\). The hexagonal test was timed by a researcher.

Statistical analyses

All analyses were performed using SPSS Version 22.0 (Chicago, IL) and GraphPad Prism 6.0. (San Diego, CA). Measures of centrality and spread are presented as mean ± standard deviation (SD). All physiological and psychological responses (i.e., the dependent variables) to the 24 exercise order combinations were pooled into one of four possible sequences. For example, all the heart rate responses to cardiorespiratory exercise when cardiorespiratory exercise was sequenced first in the exercise session were combined. In a similar manner, heart rate responses to cardiorespiratory exercise were also combined when cardiorespiratory exercise was sequenced second, third, and fourth, respectively. This was done for each of the four types of exercise (cardiorespiratory, resistance, flexibility, and neuromotor). Polynomial trend analyses were then performed to determine if there was a linear pattern to dependent variables with each sequence of exercise type. Additionally, a one-way analysis of variance (ANOVA) with repeated measures were used to examine differences in all dependent variables (cardiorespiratory heart rate; resistance exercise RPE; neuromotor 5-10-5 test score, left leg squat test score, right leg squat test score, and hexagonal agility test score; and sit-and-reach test score). If a significant F ratio was obtained, Tukey’s post hoc tests were used to locate differences between means. The probability of making a type I error was set at p<0.05 for all statistical analyses.

RESULTS

The ExRx was well tolerated with 100% adherence for the 20 of 24 participants who completed the study. Four participants were unable to complete the study for the following reasons: injury outside the study (n = 2), illness (n = 1), and personal reasons (n = 1). All analyses and data presented in the results are for those participants who completed the investigation. The physical and physiological characteristics of participants are
presented in Table 1. Physiological and psychological responses to all exercise order combinations are shown in Table 2.

**Cardiorespiratory exercise**

The mean heart rate response to cardiorespiratory exercise (mean treadmill speed = 7.9 kmh) was significantly different (p<0.05) across exercise sequence positions. In fact, post hoc tests showed that all mean heart rate responses across the four possible exercise sequence positions were significantly different from each other. There was a 12 beats per minute (bpm) difference in mean HR response to cardiorespiratory exercise when cardiorespiratory exercise was sequenced first when compared to last in the ExRx. When cardiorespiratory exercise was performed first the HR response equated to 56% HRR (i.e., moderate-intensity exercise). In contrast, the mean HR response equated to 66.7% HRR (i.e., vigorous-intensity exercise) when cardiorespiratory exercise was sequenced last in the exercise session. Trend analysis showed that the mean heart rate response to cardiorespiratory exercise continued to increase in a linear manner the further cardiorespiratory exercise was prescribed in the exercise session (Figure 2).

**Figure 2:** Heart rate response to cardiorespiratory exercise (A) and resistance exercise RPE (B) across exercise sequence. Columns, means; error bars, SDs.
Table 2: Physiological responses to cardiorespiratory (A), resistance (B), neuromotor (C), and flexibility (D) exercise for all orders of exercise.

<table>
<thead>
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<th>Order of Exercises</th>
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The ExRx consisted of standardized exercise sessions performed in all possible sequences (1-24) using a counterbalanced experimental design.

*aMean ± SD for cardiorespiratory exercise (HR – bpm).
*bMean ± SD for resistance exercise (RPE).
*cMean ± SD for neuromotor performance measures, including 5-10-5 shuttle test (sec), left leg squat test (repetitions), right leg squat test (repetitions), and hexagonal agility test (sec).
*dMean ± SD for flexibility exercise (sit and reach test – cm).
Resistance exercise
The mean resistance exercise RPE was significantly different (p<0.05) across exercise sequence positions. Mean resistance exercise RPE was similar (p>0.05) when resistance exercise was positioned either first or second in the ExRx; however, post hoc tests showed mean resistance exercise RPE was significantly higher (p<0.05) when the resistance exercise component was positioned third or fourth in the ExRx when compared to first or second. Trend analysis showed there was a linear increase in mean resistance exercise RPE the further that resistance exercise was prescribed in the ExRx (Figure 2).

Neuromotor and flexibility exercise
There were no significant differences (p>0.05) in the physiological responses to either neuromotor or flexibility exercise across all exercise sequence positions. Likewise, trend analyses exhibited no change (increase or decrease) in any of the neuromotor or flexibility measures when these types of exercise were prescribed at a later point in the ExRx (Figures 3 and 4).

DISCUSSION
The main finding of the present study is that there is a significant effect of exercise order on the acute physiological and psychological responses to an exercise session. Indeed, heart rate responses to cardiorespiratory exercise and resistance exercise RPE values were significantly higher when these types of exercise were sequenced later in the exercise session. In contrast, physiological responses to flexibility and neuromotor exercise were not influenced by exercise order. Although it is well-established that regular exercise confers
numerous health benefits, to our knowledge, the
effect of exercise order on physiological and
psychological measures when combining all four
exercise types recommended in the most recent
ACSM guidelines within the same session has not
been previously scientifically explored. As such, the
results of this novel study are encouraging and
provide important preliminary data towards
formulating recommendations for an optimal
sequence of cardiorespiratory, resistance, flexibility,
and neuromotor exercise for the ExRx.

Despite a large body of evidence demonstrating
the beneficial health effects linked to the
development and maintenance of cardiorespiratory,
resistance, flexibility, and neuromotor exercise,
there is currently limited data on the best strategy
for the ExRx when all 4 types of exercise are
combined within a single exercise session. Previous
research on concurrent exercise programs have
reported significant effects on the sequencing of
cardiorespiratory and resistance exercise training
within the same training session. For example, a
higher heart rate response has been reported when
cardiorespiratory exercise followed rather than
preceded resistance exercise (172 versus 161 bpm;
p<0.05). Our findings were comparable as heart
rate responses were consistently higher when
cardiorespiratory exercise was sequenced further in
the exercise session (137 [cardiorespiratory exercise
first] versus 149 [cardiorespiratory exercise last]
bpm; p<0.05). In fact, when cardiorespiratory
exercise was sequenced last (66.7% HRR) when
compared to first (56% HRR) in the exercise
session, the exercise intensity exceeded the
prescribed moderate intensity threshold and
subsequently fell within the vigorous exercise
intensity domain. Given that the cardiorespiratory
ExRx in the present study called for moderate
intensity exercise this finding was unexpected; and
may have important practical implications for
exercise professionals and the ExRx. First, although
overall adherence in the present study was high,
previous research has reported that individuals may
adhere to moderate-intensity exercise to a greater
extent when compared to vigorous intensity
exercise. As such, the higher than prescribed heart
rate response (i.e., vigorous exercise intensity) to
cardiorespiratory exercise when sequenced at a
latter point in the exercise session may over the
long-term result in poorer adherence to regular
exercise training. Second, unexpected vigorous-
intensity exercise may contribute to increased
musculoskeletal injury. Furthermore, it has also
been reported that acute myocardial infarction and
sudden cardiac death can be triggered by
unaccustomed vigorous physical exertion.

Although the likelihood of the later scenario is rare,
it nonetheless underpins the possible consequences
of an incorrect exercise order. Taken together, the
present findings placed in the context of the
literature, support the recommendation for
cardiorespiratory exercise to be sequenced first
overall in the exercise order when multiple types of
exercise are performed in the same session.

Previous research has found that resistance
exercise was negatively impacted, possibly due to
muscle fatigue, when sequenced after
cardiorespiratory exercise. Conversely, results from
the present study showed similar resistance exercise
RPE values when resistance exercise was performed
after (when compared to before) a bout of
cardiorespiratory exercise. Moreover, resistance
exercise RPE values were also similar when
resistance exercise was sequenced after (when
compared to before) either a bout of flexibility or
neuromotor exercise. However, when resistance
exercise was performed after two or three previous
bouts of exercise (i.e., third or fourth in the overall
sequence of exercise types), and despite the fact
that the same standardised resistance exercise workload was performed for all exercise sessions, it was found that resistance exercise RPE was significantly higher. An interference phenomenon is the most common reason offered for an order effect when multiple types of exercise are combined within a single session\(^\text{21}\). It has been reported that residual fatigue from the first bout of exercise can compromise tension development of the skeletal muscles specific to the muscles involved in the later bouts of exercise\(^\text{22}\). Unlike the physiological and psychological responses to cardiorespiratory and resistance exercise, the present study showed similar flexibility and neuromotor exercise responses irrespective of location in the exercise session. Collectively, these findings suggest resistance exercise should be sequenced second in the exercise session (following cardiorespiratory exercise), with flexibility and neuromotor exercise interchangeable as the third and fourth bouts of exercise when all types of exercise are combined within a single session.

The ACSM recommends a comprehensive program of exercise including cardiorespiratory, resistance, flexibility, and neuromotor exercise of sufficient volume and quality as outlined below in Table 3 for apparently healthy adults of all ages\(^\text{9}\).

An exercise program that meets these criteria will improve overall physical and mental health in most persons. Yet for the frequency recommendations of each type of exercise to be satisfied it should be evident from Table 3 that individuals will need to perform at least two (or more) types of exercise the same day; and most likely within the same exercise session.

Findings from the present study have important implications for the safety and effectiveness of the ExRx. It was found in the present study that there was a significantly higher heart rate response to cardiorespiratory exercise (into the vigorous exercise intensity domain) when it was sequenced further in the exercise session. Unaccustomed vigorous-intensity exercise may lessen adherence, increase the risk of musculoskeletal injury, and increase the risk of acute cardiac events. Given that the health benefits accrued from engaging in regular cardiorespiratory exercise far exceed those received from other types of exercise, it would appear unwarranted to possibly compromise an individual fulfilling weekly cardiorespiratory exercise recommendations on a regular basis by prescribing an incorrect exercise order. Our findings showed resistance exercise RPE was similar when resistance exercise was performed either first or second in the

**Table 3:** Frequency, intensity, and time guidelines for cardiorespiratory, resistance, flexibility, and neuromotor exercise.

<table>
<thead>
<tr>
<th>Type of exercise</th>
<th>Frequency</th>
<th>Intensity</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardiorespiratory</td>
<td>5 days/wk moderate intensity; 3 days/wk vigorous intensity; or combination of both.</td>
<td>Moderate intensity corresponds to brisk walk with noticeable heart rate. Vigorous intensity equivalent to jogging resulting in significant heart rate and quick breathing.</td>
<td>For moderate intensity activities, accumulate at least 30 min/day; for vigorous intensity activities, accumulate at least 20/min day</td>
</tr>
<tr>
<td>Resistance</td>
<td>2-3 days/wk</td>
<td>A resistance exercise that permits 8 to 12 reps, equivalent to ~60% to 80% of one repetition maximum.</td>
<td>Complete 2 to 4 sets for each muscle group. Permit 2 to 3 min rest intervals between each set.</td>
</tr>
<tr>
<td>Flexibility</td>
<td>2-3 days/wk</td>
<td>Exercises should be performed to the point of mild discomfort within the natural range of motion.</td>
<td>Complete up to 4 reps per muscle group, 15-60 sec per static stretch. Overall duration at least 10 min.</td>
</tr>
<tr>
<td>Neuromotor</td>
<td>2-3 days/wk</td>
<td>Currently unknown</td>
<td>≥ 20-30/day may be needed</td>
</tr>
</tbody>
</table>

Modified from Garber et al. 20
exercise order. However, when resistance exercise was performed third or fourth in the exercise order, resistance exercise RPE was significantly higher. Long-term, a greater level of physical strain may impact exercise adherence. Additionally, there is a mistaken belief that a cardiorespiratory-resistance exercise order will negatively impact muscular fitness development. However, this perception is unsupported by the scientific literature. In fact, a recent study clearly showed that intra-session sequencing of aerobic and resistance activities do not negatively influence the change in muscular fitness. At the conclusion of a 3-month investigation, it was reported that the improvements in maximal muscular strength, strength endurance, and explosive strength and power were comparable between aerobic-resistance and resistance-aerobic groups\textsuperscript{23}. Unlike cardiorespiratory and resistance exercise which were significantly impacted by sequence of exercise, results from the present study found no order effect for either flexibility or neuromotor exercise. Given the fact that flexibility and neuromotor exercise were performed equally well regardless of overall position in the exercise order, the general recommendation can be made to order these types of exercise third and/or last in the exercise session.

CONCLUSION

When combining all four exercise type components into the same session, there are no clear guidelines for the most appropriate sequencing of activities. In the present study individuals performed 24 exercise sessions consisting of all possible exercise sequence combinations of cardiorespiratory, resistance, flexibility, and neuromotor exercise. The ExRx for each session was designed to ensure current evidence-based guidelines for frequency, intensity, and time (see Table 3) were fulfilled for each type of exercise. Results from the current study provide important preliminary data towards formulating recommendations for an optimal sequence of cardiorespiratory, resistance, neuromotor and flexibility exercise for the ExRx.

Practical application

- Cardiorespiratory exercise should always be sequenced first in the exercise order.
- Resistance exercise should be sequenced second in the exercise order and follow cardiorespiratory exercise.
- Flexibility and Neuromotor exercise

CONCLUDES the exercise session

REFERENCES


