THE EFFECTS OF EXERCISE ON BIRTH WEIGHT: 
A META-ANALYSIS

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Abstract: Previous research regarding the effects of exercise on pregnancy outcomes has been inconsistent. The purpose of this study was to adopt an objective research technique, meta-analysis, to summarize and analyze different studies with controversial results. Three coding variables (i.e., exercise duration, pre-pregnancy weight, and age) were selected in this study for comparisons. Though the effect size (ES) of the pregnant mothers who exercised under 30 minutes was greater than that of those who exercised between 30 and 60 minutes, the overall ES (-107.838, 95% CI = -482.93 to 267.26) indicated no significant birth weight differences between the two groups. On the whole, the results of this study support the notion that a significant positive relationship exists between birth weight and the pre-pregnancy weight. However, regression analysis indicated that a significant (p < .05) positive relationship existed between birth weight and the pre-pregnancy weight of the pregnant mothers (R = .75, p = .04). The conclusions of this study should be cautiously interpreted since they are limited to the selected studies under investigation. Directions and recommendations for future research are discussed.

Physiological factors such as cardiac output, oxygen consumption, hormones, etc. will alter when a person exercises. Such physiological variables also change during pregnancy (Bell & O’Neill, 1994; Gorski, 1985; Spatling, Fallenstein, Huch, Huch, & Rooth, 1992). The combined effects of exercise during pregnancy are a major concern for most medical care providers, educators, the general public, as well as pregnant women and their families. The most common question being raised is whether oxygen and nutrients are shunted from the uterus to the working muscles during exercise. As a consequence, will women deliver immature or underweight babies because of exercise activity during pregnancy?

Previous research studies have indicated that low birth weight (i.e., not more than 2500 g) babies were inferior to normal weight babies in reference to future growth and development. There appears to be a higher frequency of learning disabilities and behavioral problems (McCormick, Gortmaker, & Sobol, 1990; Ornstein, Ohlsson, Edmonds, & Asztalos, 1991; Sommerfeldt, Ellersten, & Markestad, 1996; Sommerfeldt, Troland, Ellersten, & Markestad, 1996; Szatmari, Saigal, Rosenbaum, Campbell, & King, 1990), lower Intelligence Quotient (Ornstein, Ohlsson, Edmonds, & Asztalos, 1991; Pharoah, Stevenson, Cooke, & Stevenson, 1994; Sommerfeldt, Ellersten, & Markestad, 1995), and motor clumsiness such as impaired balance (Largo et al., 1989; Marlow, Roberts, & Cook, 1989) among low birth weight babies.

The direct causes of low birth weight babies are not fully understood. However, many factors have been examined to determine their effects on pregnancy outcomes. These factors include supplements (e.g., Scholl & Johnson, 2000), nutrition (e.g., Breslin, 1998), and exercise (see Pivarnik, 1998 and Sternfeld, 1997 for a thorough review). Among these factors, the most controversial one seems to be the effects of exercise on pregnancy outcomes, par-
particularly on the changes in birth weight. In their study, Bell, Palma, and Lumley (1995) compared women who were doing vigorous exercise prior to pregnancy and continued exercising during pregnancy with those who did not do regular vigorous exercise (controls). They found women who did more than 4 sessions (30 minutes each session) of vigorous exercise weekly at 25 weeks gestation had babies whose mean birth weight was 315g lower than their counterparts. Other studies also supported the idea that strenuous physical activity in pregnancy could be associated with low birth weight and earlier deliveries (Bell & O’Neill, 1994; Clapp & Dickstein, 1984).

Researchers also indicated that a number of other factors seem to be related to poor pregnancy outcomes, as well. These factors may include, but are not limit to, the following: (a) maternal weight prior and during pregnancy (e.g., Cnattingius, Bergström, Lipworth, & Kramer, 1998; Edwards, Hellerstedt, Alton, Story, & Himes, 1996; Kumari, 2001; Ogunyemi, Hullett, Leeper, & Risk, 1998), (b) maternal nutrition, such as nutrient deficiencies or toxicities, use of some herbal supplements, eating disorders (e.g., Brown & Kahn, 1997; Story & Alton, 1995), (c) socioeconomic issues, like poverty, low levels of education, limited availability of food (e.g., Jonas, Roder, & Chan, 1992; Otterblad-Olausson, Cnattingius, & Goldenberg, 1997), (d) lifestyle choices, such as smoking, alcohol or other drug use (e.g., Kallen, 2001; Korea, Pastuszak, & Ito, 1998), (e) age, for example, teens and women over age 35 (e.g., Gortzak-Uzan, Hallak, Press, Katz, & Shoham-Vardi, 2001; Seoud et al., 2002), (f) previous pregnancies, such as short intervals between pregnancies, poor prior pregnancy outcomes, multiple births (e.g., Meyer, Buescher, & Surles, 1999; Zhu, Haines, Le, McGrath-Miller, & Boulton, 2001), and (g) maternal health concerns, like high blood pressure, diabetes, or other chronic diseases (e.g., Lopez, Smith, & Gutierrez, 2002; Sibai, 1996; Xiong, Demianczuk, Saunders, Wang, & Fraser, 2002).

Pivarnik, Maurer, Ayres, Kirshon, Dildy, and Cotton (1994), however, compared nine aerobically trained, physically active pregnant women who continued to exercise throughout gestation with five healthy yet sedentary pregnant women. They concluded that average birth weight and length of gestation did not significantly differ between the subject groups. Sternfeld, Quesenberry, Eskenazi, and Newman (1995) investigated the effect of different aerobic exercise levels on pregnancy outcomes with 388 women between the ages of 18 and 42 and found that exercise levels were not associated with mean birth weight and other pregnancy outcomes. Several other studies also indicated that physical activity was not associated with changes in birth weight (Dale, Mullinax, & Bryan, 1982; Jarrett & Spellacy, 1983; Rice & Fort, 1991; Rose, Haddow, Palomake, & Knight, 1991).

Conversely, after assessing 800 prenatal patients, Hatch et al. (1993) asserted that in fit and low-risk patients, exercise was positively related to fetal growth. They indicated that low to moderate exercise level patients had a mean birth weight about 100 g higher than the non-exercisers. In addition, large birth weight increments (about 300 g) were found for those who exercised throughout pregnancy at levels approximating 3,000 Kcal per week. Similarly, Brodey (1993) also concluded that pregnant women who expended up to 1,000 Kcal a week doing both high and low impact activities (e.g., stationary biking, aerobics, jogging, and strength training) delivered babies who weighed 5% more than those by the sedentary mothers. Comparatively, mothers who expended 2,000 Kcal a week delivered babies weighing 10% more (Brodey, 1993). Likewise, Johnson et al. (1994) demonstrated that exercise was associated with higher mean birth weight and head circumference in African American pregnant women.

Because of the controversy in these studies regarding the effects of maternal exercise on birth weight, there is a need to quantitatively and objectively summarize the findings of related studies. The purpose of this paper was to summarize and analyze studies regarding the effects of maternal exercise on birth weight using meta-analysis (Glass, 1977; Hedges & Olkin, 1985). Meta-analysis is a strategy that statistically analyzes summary findings of empirical research (Glass, 1977). Hedges and Olkin (1985) described meta-analysis as “the rubric used to describe quantitative methods for combining evidence across studies” (p. 13).

The outcome of the meta-analysis is derived from four steps. First, evaluations relevant to a specific topic are collected. Secondly, specific features of these evaluations are described quantitatively. Next, outcomes are formulated into a common measure called the effect-size, the standardized difference between the experimental and the control groups on a specific criterion. Finally, the researcher utilizes statistical methods to find relations between study features and study outcomes (Bangert-Drowns, 1986). Since meta-analysis usually relies on “data” in the form of summary statistics derived from the primary analyses of studies, it can be regarded as an analysis of the results of statistical analyses (Hedges & Olkin, 1985).

METHOD

All of the research articles selected for this study were based on a literature exploration using (a) com-
puter was restricted to the following databases: Medline, ProQuest Direct, PsycINFO, ERIC, SPORT Discuss, and Books & Dissertations. The hand search was based on the references listed in journal articles and books/dissertations. The key words used for computer search were 'exercise', 'pregnancy', 'pregnancy outcome', and 'birth weight'. According to the aforesaid procedures in the literature search, 40 articles were identified to be related to the topic under investigation and appropriate for initial review. A majority of the articles came from Medline, while ERIC provided the least number of articles. After a thorough examination of the 40 articles, 31 of them did not meet the criteria for this study because one or more of the following criteria were missing: (a) standard deviation, e.g., Dale, Mullinax, & Bryan, 1982; Hall & Kaufmann, 1987; (b) sample size, e.g., Clapp, 1996; (c) control group, e.g., Jarrett & Spellacy, 1983; or (d) other reasons such as using animals as subjects (e.g., Matsuno, Esrey, Perrault & Koski, 1999). As a result, only nine studies that met the criteria for meta-analysis were selected.

In this study, nine studies were examined to determine the effects of exercise duration on birth weight. To meet the criteria to be included in this meta-analysis, all of the following elements needed to be present in a study: (a) use birth weight as the dependent variable, (b) provide sample size, mean and standard deviation for each group; if not, provide values of the F ratio or c2 with degrees of freedom, and (c) have acceptable measurement quality, e.g., the use of a control group. Because the purpose of this study was to examine the effects of exercise on birth weight, exercise duration was selected as the coding variable. Two other variables of interest, pre-pregnancy weight and age, which might potentially influence the effect sizes also were coded. Due to the limited number of studies, exercise duration was divided into two levels: (a) those who exercised up to but not more than 30 minutes, and (b) those who exercised between 30 and 60 minutes. The total sample size of the nine articles used for this study was 951.

The MetaWin Version 2.0 (Rosenberg, Adams, & Gurevitch, 2000) computer program was used to examine (a) the differences of birth weight, age, and pre-pregnancy weight between the exercise group and control group, and (b) the effect size of birth weight between pregnant mothers who exercised less than 30 minutes versus those who exercised between 30 and 60 minutes. In addition, linear regression analyses were used to examine (a) the relationship between birth weight and age as well as pre-pregnancy weight of the experimental group, and (b) the relationship of age and pre-pregnancy weight differences between the experimental group and control groups.

RESULTS

A total of 951 pregnant women were included in this study, 542 participants in the experimental group and 409 participants in the control group. Descriptive statistics and birth weight of the experimental and control groups are shown in Table 1. The effect size (ES) of the birth weight differences between the experimental and control groups was -109.20 (95% CI = -432.071 to 213.663). This indicated no significant birth weight differences between the two groups since the confidence intervals crossed zero. Similarly, no significant pre-pregnancy weight differences were found between the experimental and control groups (ES = -0.776, 95% CI = -2.406 to 0.853). However, the age of the experimental group mothers was slightly higher than their counterparts (ES = 0.743, 95% CI = 0.006 to 1.480). In spite of this, the age of the experimental and control group mothers was very similar since such a small ES (i.e., 0.74) was not considered clinically important. On the other hand, when examining the birth weight of those who exercised under 30 minutes versus those who exercised between 30 and 60 minutes, both groups had a negative ES. The ES of the former was -236.047 while that of the latter was -4.143. Though the pregnant women who exercised a longer duration had a smaller absolute ES value, the overall ES (-107.838, 95% CI = -482.93 to 267.26) indicated no significant birth weight differences between the two groups because the confidence intervals crossed zero.

Since age and pre-pregnancy weight could act as confounding variables, their relationship with birth weight was examined. Liner regression analyses indicated no significant (p > .05) relationship between birth weight and the age of the experimental group (R = .04, p = .91) as well as the pre-pregnancy weight differences of the exercise and control groups (R = .05, p = .46). However, significant (p < .05) positive relationship was found between birth weight and the pre-pregnancy weight of the experimental group (R = .75, p = .04).

DISCUSSION

The purpose of this study was to use meta-analysis to examine the effects of exercise on birth weight. Only nine of the 40 articles reviewed were used for this study because the remainder did not meet the criteria for a meta-analysis. It seems that it is not a common practice in medical articles to provide standard deviations for the results (for examples, Dale, Mullinax, & Bryan, 1982; Hall & Kaufmann, 1987;
Table 1. Descriptive Statistics of the Experimental and Control Groups.

<table>
<thead>
<tr>
<th>Source</th>
<th>Experimental Group</th>
<th>Control Group</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Pre-pregnancy</td>
<td>Pre-pregnancy</td>
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<tr>
<td></td>
<td>Birth weight (kg)</td>
<td>Birth weight (gram)</td>
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<tr>
<td></td>
<td>N</td>
<td>N</td>
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<tr>
<td>Horns et al. (1996)¹</td>
<td>28.4 ± 4.1</td>
<td>27.2 ± 3.8</td>
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<tr>
<td></td>
<td>2496 ± 486</td>
<td>3467 ± 434</td>
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<tr>
<td></td>
<td>48</td>
<td>53</td>
</tr>
<tr>
<td>Lewis et al. (1988)¹</td>
<td>28.4 ± 3.2</td>
<td>27.3 ± 3.4</td>
</tr>
<tr>
<td></td>
<td>59.4 ± 8.4</td>
<td>62.8 ± 10.6</td>
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<tr>
<td></td>
<td>3400 ± 700</td>
<td>3700 ± 500</td>
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<td></td>
<td>18</td>
<td>10</td>
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<tr>
<td>Hatch et al. (1993)¹</td>
<td>27.9 ± 4.6</td>
<td>27.1 ± 4.4</td>
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<tr>
<td></td>
<td>62.2 ± 14</td>
<td>62.5 ± 11.7</td>
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<tr>
<td></td>
<td>3554 ± 382</td>
<td>3389 ± 488</td>
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<td></td>
<td>277</td>
<td>185</td>
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<tr>
<td>Botkin &amp; Driscoll (1991)¹</td>
<td>28.1 ± 5.1</td>
<td>27.2 ± 5.5</td>
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<tr>
<td></td>
<td>3664 ± 318</td>
<td>3523 ± 351</td>
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<tr>
<td></td>
<td>19</td>
<td>25</td>
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<tr>
<td>Bell et al. (1995)²</td>
<td>31.8 ± 2.7</td>
<td>31.6 ± 4.7</td>
</tr>
<tr>
<td></td>
<td>58.8 ± 6.9</td>
<td>59.1 ± 7.6</td>
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<tr>
<td></td>
<td>3353 ± 589</td>
<td>3364 ± 412</td>
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<tr>
<td></td>
<td>58</td>
<td>41</td>
</tr>
<tr>
<td>Clapp &amp; Capeless (1990)²</td>
<td>30.6 ± 2.5</td>
<td>30.1 ± 3.3</td>
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<td></td>
<td>57.7 ± 5.2</td>
<td>58.1 ± 5.9</td>
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<tr>
<td></td>
<td>3381 ± 322</td>
<td>3691 ± 348</td>
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<tr>
<td></td>
<td>77</td>
<td>55</td>
</tr>
<tr>
<td>Rice &amp; Fort (1991)²</td>
<td>23.3 ± 3.6</td>
<td>26.2 ± 5.1</td>
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<td></td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>3500 ± 318</td>
<td>3455 ± 450</td>
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<tr>
<td></td>
<td>12</td>
<td>11</td>
</tr>
<tr>
<td>Collings et al. (1983)²</td>
<td>26.9 ± 2.8</td>
<td>28.0 ± 3.7</td>
</tr>
<tr>
<td></td>
<td>60.3 ± 8.3</td>
<td>64.4 ± 8.4</td>
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<tr>
<td></td>
<td>3596 ± 480</td>
<td>3354 ± 415</td>
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<tr>
<td></td>
<td>12</td>
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<tr>
<td>Kardel &amp; Kase (1998)²</td>
<td>28.8 ± 2.3</td>
<td>26.7 ± 1.7</td>
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<tr>
<td></td>
<td>59.4 ± 6.3</td>
<td>63.0 ± 8.9</td>
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<tr>
<td></td>
<td>3651 ± 516</td>
<td>3591 ± 532</td>
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<tr>
<td></td>
<td>21</td>
<td>21</td>
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Data reported as mean ± standard deviation

¹Group 1: Exercised under 30 minutes
²Group 2: Exercised 30 to 60 minutes
in birth weight. On the other hand, the significant positive relationship found between birth weight and the pre-pregnancy weight was not surprising since numerous previous research studies also found a strong positive relationship between pre-pregnancy weight and birth weight as well as between maternal weight gain and birth weight (Abrams & Laros, 1986; Abrams & Neuman, 1989; Abrams & Selvin, 1995; Brown, 1988; Frenzen, Dimperio, & Cruz, 1988; Garn, Shaw, & McCabe, 1977; Hediger, Scholl, & Salmon, 1989; Hediger, Scholl, Belsky, Ances, & Salmon, 1989; Institute of Medicine, 1990; Naeye, 1979; Nahum, Stanislaw, & Huffaker, 1998; Scholl, Hediger, Ances, Belsky, & Salmon, 1990; Thorsdottir & Birgisdottir, 1998; Wen, Goldenberg, Cutter, Hoffman, & Cliver, 1990). For example, Thorsdottir and Birgisdottir (1998) found in their study that women who gained between 18 and 24 kg had babies approximately 300 g heavier than those who gained between 9 and 15 kg.

The purpose of this study was to introduce one of the many techniques that could summarize and analyze similar studies with inconsistent results. In 1991, Lokey, Tran, Wells, Myers, and Tran used “a meta-analytic review” to examine the effects of physical exercise on pregnancy outcomes. However, they used t-tests to compare the mean differences of the exercising and sedentary groups and no ES was reported. Based on a review of the literature, this is the first meta-analysis study to examine the effects of exercise on birth weight using a meta-analysis computer program and ES to determine the overall magnitude of two comparing groups. Only three variables, exercise duration, age, and pre-pregnancy weight, were examined in this study. Another potential variable that should be considered in future studies is ethnicity since black infants tended to weigh less and be twice as likely as white babies to have a low birth weight (Breslin, 1998).

On the whole, the results of this study support the notion that a significant positive relationship exists between birth weight and the pre-pregnancy weight. This conclusion is based on the results of the meta-analysis of selected publications. Of course, many other factors other than the aforesaid variables also may affect pregnancy outcomes. These factors may include maternal weight, maternal nutrition, socioeconomic status, lifestyle habits, age, poor previous pregnancy outcomes, and maternal health. It is suggested that for future medical studies, efforts should be implemented to control for potential confounding factors when manipulating independent variables and assessing dependent variables. In addition, in order to facilitate future studies using meta-analysis, the researchers recommend the following information to be included in all publications: (a) sample size, (b) experimental and control groups, (c) mean and standard deviation of the dependent variables, (e) the type of statistical analysis, and (f) the results of statistical analysis.

REFERENCES


Breslin, M. (1998). Women’s birth weight and intrauterine nutrition may have an effect on their infant’s birth weight. *Family Planning Perspectives, 30*, 148-149.


References with * were used for the meta-analysis.