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PREVETT, Christina, KIMBER, Miranda L, FORNER, Lori, DE VIVO, Marlize <http://orcid.org/0000-0002-7873-5985> and DAVENPORT, Margie H <http://orcid.org/0000-0001-5627-5773>

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Christina Prevett[1], Miranda L. Kimber[2], Lori Forner[3], Marlize de Vivo[4], Margie H Davenport[2]

[1]Institute of Clinical Excellence, United States

[2]Program for Pregnancy and Postpartum Health, Physical Activity and Diabetes Laboratory, Faculty of Kinesiology, Sport and Recreation, Women and Children's Health Research Institute, Alberta Diabetes Institute, University of Alberta, Edmonton, Alberta, Canada.

[3] The University of Queensland, Brisbane, Australia.

[4]Canterbury Christ Church University; Active Pregnancy Foundation, United Kingdom.

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- ML Kimber: Survey development on REDcap, data analysis, and manuscript writing
- L Forner: Survey creation and manuscript writing
- M de Vivo: Survey creation and manuscript writing
- MH Davenport: Survey creation, survey development on REDcap, and manuscript writing

Corresponding Author

Margie H. Davenport, PhD
1-059D Li Ka Shing Centre for Health Research Innovation
8602 - 112 St
Edmonton, Alberta, Canada, T6G 2E1
Tel: (780)492-0642
Email: mdavenpo@ualberta.ca

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Abstract

Introduction: Participation in Olympic weightlifting, the Valsalva maneuver, and acute or prolonged supine weightlifting during pregnancy are cautioned against, however, these recommendations are based on expert opinions as opposed to empirical evidence. The aim of this study was to examine the training and health outcomes of individuals who engaged in heavy resistance training during pregnancy. ***Methods***: 679 individuals who lifted at least 80% 1-repetition maximum during pregnancy participated in an online survey. ***Results***: Participants were primarily recreational athletes (88%, n = 332/673) engaged in CrossFit™ (61%, n = 410/675) and/or weightlifting (49%, n = 332/675) during pregnancy. Most participants reported no complications during pregnancy or delivery (66%, n = 388/589), while 57% (n = 241/426) reported urinary incontinence following pregnancy. Participants who maintained pre-pregnancy training levels until delivery reported significantly less reproductive complications compared to those who ceased training levels prior-to delivery (p = 0.006). Most respondents engaged in Olympic lifting (72%, n = 311/432) and lifting in a supine position (71%, n = 306/437), while fewer reported use of the Valsalva maneuver during pregnancy (34%, n = 142/412). Most returned to weightlifting following delivery (89%, n = 400/447, average: 3.2 ± 3.0 months), including Olympic lifting (81%, n = 300/372, average: 4.0 ± 3.4 months) and Valsalva (62%, n = 213/341, average: 4.5 ± 3.6 months). ***Conclusions***: Individuals who engaged in heavy prenatal resistance training had typical perinatal and pelvic floor health outcomes that were not altered whether they engaged in, or avoided Olympic lifting, Valsalva or supine weightlifting.

Key words: weightlifting, prenatal, postnatal, Valsalva, Olympic weightlifting, supine weightlifting.

Brief Summary:

Women who engaged in heavy prenatal resistance training, including contraindicated activities such as Olympic lifting, Valsalva or supine weightlifting, reported typical perinatal health outcomes.

Introduction

Female participation in strength-focused sports such as CrossFit™, weightlifting and powerlifting has risen dramatically over the last decade.(1, 2) Due to a lack of data supporting

safe participation in heavy/strenuous weightlifting, prenatal physical activity guidelines discourage Olympic lifting, Valsalva maneuver and acute and/or prolonged weightlifting in the supine position.(3-6) However, these recommendations are largely based on expert opinion as opposed to empirical evidence.

Traditionally pregnant individuals were discouraged from engaging in heavy lifting based on evidence in an occupational setting where repetitive lifting more than 11kg was associated with an increased risk of having a miscarriage, developing preeclampsia or having a preterm delivery.(3, 7) However, occupational lifting and heavy weightlifting in a recreational setting are vastly different and cannot be equated to establish the potential for adverse pregnancy outcomes. Under recreational settings, dynamic movements at intensities to improve metabolism typically occur over a short period of time (<60 minutes), and allow sufficient time to recover. In contrast, chronic physically demanding activities in an occupational setting generally do not include sufficient rest or recovery may induce physiological "overtraining", fatigue, psychological stress and detrimental health effects.(8) Further, concerns of excessive stress on the pelvic floor from heavy weightlifting also inspire recommendations to avoid these activities during pregnancy. Evidence demonstrates non-pregnant female athletes who participate in powerlifting, CrossFit™, and weightlifting have a higher incidence of stress urinary incontinence (UI) during heavy lifting and high-impact activities.(9-12) During pregnancy up to 75% of pregnant individuals experience UI prior to delivery,(13) and the combination of heavy weightlifting and pregnancy could exacerbate the risk of UI. However, the combined impact of pregnancy and heavy weightlifting on UI is unknown.

Prenatal physical guidelines recommend avoiding the Valsalva maneuver due to concerns surrounding the substantial, but transient, increase in maternal blood pressure. Two studies have demonstrated that the Valsalva maneuver during pregnancy is not associated with any adverse

acute maternal outcomes; (14, 15) however, both were completed at relatively low training loads (up to maximum of 50 lbs with incline bench press(14) and 40% of 10 repetition maximum [RM] in a seated leg press).(15) Acute and/or prolonged supine exercise, particularly after 16 weeks of gestation, has been cautioned against for decades.(16) Evidence has demonstrated that supine positions during pregnancy compress the maternal inferior vena cava (IVC) and aorta which may result in maternal hypotension and reduced fetal oxygenation.(17-19) A recent review observed that despite compression of the IVC in the supine position, the majority of pregnant individuals do not demonstrate symptoms of hypotension.(20) At this time evidence remains inconclusive if acute or prolonged supine exercise during pregnancy is associated with adverse outcomes.(21, 22)

Given the distinct lack of empirical evidence supporting (or not) the safety of heavy weightlifting (including supine and Olympic weightlifting) and the Valsalva maneuver, the aim of the present study was to examine whether females who continued to participate in heavy resistance training during pregnancy (>80% 1RM) were at heightened risk for adverse birth outcomes, adverse fetal outcomes or pelvic floor dysfunction.

Methods

Survey

The questionnaire was developed by pelvic floor physiotherapists (C.P., L.F.), exercise physiologists (M.H.D., M.K.), biokineticist and sports rehabilitator (M.D.), and an elite-level weightlifter (C.P.) from Canada, the United States, Australia and the United Kingdom. The public was not involved in the design of this study. The survey was piloted with a small group of female athletes to assess the feasibility, usability and clarity of the survey. The questionnaire consisted of 60 questions and took 20-30 minutes to complete. Question domains included maternal demographics, sport history, reproductive history, pregnancy health outcomes, and pre-

pregnancy/pregnancy/postpartum aerobic and resistance training characteristics. Respondents were asked about any signs or symptoms of pelvic floor dysfunction (leaking, heaviness, symptoms of prolapse, pain) during and following pregnancy. Finally, participants were asked about information sources that they used to make decisions about heavy weightlifting during pregnancy.

Participants

Between June 14 and August 21, 2021, we recruited 679 participants through social media (e.g., Instagram), word of mouth and through the authors' personal networks. Participants had to be over the age of 18 and engaged in heavy weightlifting during pregnancy (>80% 1RM). A threshold of greater than 80% was chosen as this exceeds any current resistance training literature in pregnant individuals and equates to loads higher than published guidelines have recommended due to a paucity of literature.(4-6) Electronic informed consent was provided before completing an online survey. This study was approved by the University of Alberta Health Research Ethics Board (Pro00109302) and was conducted in accordance with the Declaration of Helsinki, apart from registration in a publicly available database. Responses were collected through Research Electronic Data Capture, a web-based software hosted by the Women and Children's Health Research Institute, University of Alberta, Canada.

Statistical Analysis

After all responses were collected, all data were cleaned and verified for accuracy, and impossible (e.g., non-human body weight) data were removed. All exclusions were reviewed by M.K. and M.H.D and discarded following consensus. The mean ± standard deviation was calculated for continuous variables, and frequency of responses (*n* and %) were calculated for categorical variables. Subgroup analysis comparing training patterns and or pregnancy outcomes of pregnant individuals 1) with and without UI; 2) who performed Valsalva during pregnancy; 3)

engaged in supine lifting during pregnancy; and 4) Olympic lifts during pregnancy. To determine differences between groups, Fisher exact tests were used for categorical data, and multiple t-tests using the false discovery rate were used for continuous data. Odds ratios with 95% confidence intervals (95% CI) were calculated for all categorical variables.

Results

Participant Characteristics

Participant demographics are provided in Table 1 of the Supplement Digital Content. Most respondents were recreational athletes (88%, n = 594/673) that had been engaged in heavy weightlifting for 6.7 ± 4.1 years (range 1-30). Participants reported lifting at least 73% of their pre-pregnancy body weight during pregnancy (snatch, 73%; bench press, 85%; clean and jerk, 94%; clean, 97%; squat, 133%; deadlift, 163%).

Reproductive Outcomes

Pregnancy or delivery complications were reported by 34% of respondents during (n = 201/589), and 20% (n = 112/574) following pregnancy (see Supplement Digital Content Table 2 for the full list of complications). Rates of gestational hypertension (18/589, 3%), preeclampsia (17/589, 3%) and gestational diabetes mellitus (4/589, 1%) were below expected prevalence values for the general obstetrical population. Prevalence of pregnancy and delivery complications were largely not different between respondents who engaged in Olympic lifting, Valsalva maneuver, or supine exercise, compared with those who did not (see Supplement Digital Content Tables 3, 4, and 5). Respondents who maintained pre-pregnancy training levels until delivery reported significantly less pregnancy and delivery complications compared to those who reduced their training level prior-to delivery (OR: 0.49, 95% CI, 0.29 – 0.81, p = 0.006) (see Supplement Digital Content Table 6).

Training patterns during pregnancy

During pregnancy, eighty-five percent of respondents continued to engage in heavy weightlifting (with or without modification) until delivery, including 24% (n=108/445) who maintained their pre-pregnancy training levels throughout gestation (see Supplement Digital Content Table 7). The majority of participants engaged in Olympic weightlifting (72%, n = 311/432) and supine weightlifting (71%, n = 306/437) during pregnancy, while a minority of individuals reported performing Valsalva maneuvers during pregnancy (34%, n = 141/420).

Urinary Incontinence:

Thirty-seven percent of participants experienced UI during pregnancy. Individuals who experienced prenatal UI had a lower 1RM for squat, bench press, clean, and clean and jerk prior to conception (see Supplement Digital Content Table 8). However, all other variables were including pre-pregnancy and pregnancy training volumes, and engagement in Olympic lifting, Valsalva and supine exercise were not different between individuals who did and did not maintain continence during pregnancy (see Supplement Digital Content Tables 8 and 9).

Olympic Weightlifting, Valsalva and Supine Exercise:

Respondents who engaged in Olympic weightlifting during pregnancy had significantly higher pre-pregnancy 1RM for all six lifts, as well as duration and frequency of weightlifting sessions (see Supplement Digital Content Table 10). During pregnancy, participants who engaged in Olympic lifts were more likely to perform the Valsalva maneuver (OR: 2.12, 95% CI, 1.29 to 3.39, $p = 0.003$), and reported a greater frequency of resistance training (3.09 ± 1.20 vs. 2.55 ± 0.97 days/week; $p = 0.0007$). Remaining training outcomes were not different between groups (see Supplement Digital Content Tables 10 and 11).

Respondents who engaged in Valsalva during pregnancy had significantly higher pre-pregnancy 1RM for squat, bench, and deadlift, as well as a greater weightlifting training days per

week (4.07 ± 1.08 vs. 3.62 ± 1.13 days/week; p = <0.0001), duration per session (60.78 ± 23.13 vs. 52.29 ± 18.74 minutes; p = 0.002), and %1RM (77.92 ± 10.07 vs. 75.32 ± 10.90 %1RM; p = 0.03) (see Supplement Digital Content Table 12). Individuals who performed the Valsalva maneuver during pregnancy were more likely to participate in Olympic Lifting (OR: 1.98, 95% CI, 1.21 to 3.26, p = 0.006), supine weightlifting (OR: 3.00, 95% CI, 1.80 to 5.02, p = <0.0001) and use of a weightlifting belt (OR: 4.04, 95% CI, 2.08 to 7.67, p = <0.0001). All other outcomes were not different between groups (see Supplement Digital Content Tables 12 and 13).

Respondents who engaged in supine weightlifting during pregnancy had higher pre-pregnancy 1RM for all lifts except snatch and a greater frequency of weightlifting pre-pregnancy (3.90 ± 1.09 vs. 3.58 ± 1.19 days/week; p = 0.007) but a lower duration of vigorous intensity aerobic activity prior to pregnancy (32.82 ± 15.63 vs. 36.96 ± 18.57 minutes; p = 0.04) (see Supplement Digital Content Table 14). During pregnancy, frequency of weightlifting was higher among those who engaged in supine weightlifting (3.14 ± 1.18 vs. 2.52 ± 1.04 days/week; p = <0.0001); however, other training variables were not different between groups. Participants who engaged in supine lifting had a greater prevalence of engagement in Olympic lifting (OR: 2.01, 95% CI, 1.31 to 3.12, p = 0.002), Valsalva (OR: 3.20, 95% CI, 1.93 to 5.32, p = <0.0001) and use of a weightlifting belt (OR: 2.80, 95% CI, 1.27 to 6.65, p = 0.01). Other outcomes were not different between groups (see Supplement Digital Content Tables 14 and 15).

Training patterns following delivery

The majority of respondents returned to weightlifting approximately three months following delivery (89%, n = 400/447, average: 3.15 ± 3.0 months; see Supplement Digital Content Table 16). Those who did not return to weightlifting in the postpartum period reported needing additional time to recover (40%), not wanting to return (4%) and not having enough time (23%; see Supplement Digital Content Table 15).

Urinary Incontinence:

Experiencing UI during pregnancy did not influence whether participants returned to weightlifting, or the timing of return to activity (see Supplement Digital Content Table 17). However, being continent following delivery was associated with a 218% increase in the odds of returning to weightlifting following delivery, compared to those who experienced postpartum UI (OR: 2.18, 95% CI, 1.16 to 4.14, $p = 0.02$; see Supplement Digital Content Table 18). All other outcomes were not different between groups (see Supplement Digital Content Tables 17 and 18)

Olympic Weightlifting, Valsalva and Supine Exercise:

Respondents who participated in Olympic weightlifting were more likely to return to weightlifting (OR: 3.61, 95% CI, 1.80 to 7.03, $p = 0.0004$) faster (2.99 ± 2.83 vs. 3.73 ± 2.55 months; $p = 0.03$) than those who refrained from it during pregnancy. Further, those who engaged in Olympic weightlifting during pregnancy were more likely to return to Olympic weightlifting (OR: 3.49 95% CI, 1.96 to 6.11, $p = <0.0001$) and Valsalva maneuver (OR: 3.25, 95% CI, 1.91 to 5.55, $p = <0.0001$) postpartum, and returned to these activities more rapidly ($p = <0.0001$, $p = 0.01$, respectively) (see Supplement Digital Content Table 19). Participants who engaged in prenatal Valsalva returned to weightlifting sooner after delivery (2.68 ± 2.43 vs. 3.39 ± 3.23 months; $p = 0.02$) and were 6.33 times more likely to engage in postpartum Valsalva (95% CI, 3.64 to 10.98, $p = <0.0001$) compared to those who avoided Valsalva during pregnancy (see Supplement Digital Content Table 20). Similarly, participants who engaged in supine weightlifting during pregnancy had increased odds of returning to Olympic weightlifting (OR: 1.86, 95% CI, 1.12 to 3.15, $p = 0.03$) and Valsalva (OR: 2.03, 95% CI, 1.27 to 3.26, $p = 0.005$) in the postpartum period (see Supplement Digital Content Table 21). Other outcomes were not different between groups (see Supplement Digital Content Tables 19, 20, 21).

Information Sources about Weightlifting:

Responses revealed that most participants spoke to their healthcare provider about weightlifting during pregnancy (65%, n = 278/425) and were told to continue heavy lifting with modification (61%, n = 169/276) throughout pregnancy (see Supplement Digital Content Table 22). Respondents also sought information from pelvic floor physiotherapists (51%, n = 216/426), the internet (39%, n = 166/412) and their coach (27%, n = 112/412; see Supplement Digital Content Table 22).

Discussion

Our data demonstrate individuals who engaged in heavy resistance training before, during and following pregnancy, including "contraindicated" activities, experience low incidence of adverse reproductive and pelvic floor outcomes. Rather, perinatal health outcomes aligned with, or were lower than, population estimates for key health outcomes. Long-held theoretical concerns about heavy weightlifting, Olympic lifting, supine weightlifting and the Valsalva maneuver have limited the prescription of these movements during pregnancy resulting in a missed opportunity to derive health benefits from strength training during pregnancy. The epidemiological data collected does not support several of the theoretical risks associated with these activities for individuals with uncomplicated pregnancies. Prospective studies are needed to investigate maternal and fetal responses to heavy resistance training and address concerns of prolonged supine exercise and overhead Olympic weightlifting.

Contrary to commonly cited theoretical risks of heavy weightlifting, we demonstrate similar, or lower rates of pregnancy complications (e.g., preeclampsia, gestational hypertension) in those who continue to engage in heavy weightlifting during pregnancy compared to population estimates.(23) As a key example, we observed substantially lower rates of postpartum depression and anxiety among this sample (~7%) compared to general population estimates

(~14%). Our team has previously demonstrated that engaging in postpartum physical activity (e.g., aerobic exercise or yoga) is associated with a moderate effect size on depressive symptoms (standardized mean difference-0.48, 95% CI -0.73 to -0.22, I=42%).(24) The findings of the current study are the first to illustrate the beneficial impact of heavy weightlifting on perinatal depression. We also identified that individuals engaged in heavy weightlifting during pregnancy were less likely to report a cesarean section compared to global rates (13% compared to global prevalence of 21.1% ,95% confidence interval, 18.8 to 23.3%).(25) Additionally, we observed that respondents who continued their pre-pregnancy training levels until delivery reported significantly lower incidence of reproductive complications compared to those who reduced or ceased their resistance training levels during pregnancy. This suggests that engaging in heavy/strenuous resistance training into late pregnancy does not, or potentially decreases, odds of reproductive and delivery complications. The lower prevalence of these, and other, common perinatal complications in pregnant and postpartum individuals further highlight the urgent need for further research with this population as current recommendations to avoid these movements may conversely increase the risk of these complications.

The Valsalva maneuver is a performance aid which increases stiffness across the spine, increases electromyographic activation of the paraspinal musculature and therefore allow for increased loads to be lifted.(26) The Valsalva maneuver has been flagged as a potential area of concern for pregnant people due to the acute and substantial increase in blood pressure. The present study demonstrates that pregnant individuals are largely following this guidance as 66% of the sample avoided participation. Two previous studies failed to demonstrate an adverse effect of acute Valsalva during pregnancy;(14, 15) however, the impact of chronically engaging in the Valsalva maneuver during pregnancy has not been investigated. Our data found no difference in pregnancy, labor or delivery outcomes between those who engaged in the Valsalva maneuver

with those who did not. Similarly, acute and prolonged supine exercise during pregnancy is also cautioned against due to concerns of a transient reduction fetal blood flow, and maternal hypotension. In our sample, the incidence of reproductive complications were not different between the 71% of respondents who engaged in supine exercise during pregnancy with those who did not. We also observed no difference in reproductive outcomes between the 72% of respondents who participated in Olympic weightlifting and those who did not. Pregnant individuals may be told to avoid Olympic weightlifting due to concern of injury from falling on the stomach, contact with a barbell or overhead lifting.(27) Among our sample, the odds of obtaining an injury both during and following pregnancy were not different between those who engaged in Olympic weightlifting and those who did not. Pre-pregnancy 1RM and weightlifting volume was significantly higher among this subsample, thus experience and technique may be critical to avoiding injury during pregnancy. These data provide preliminary support for the safety of engaging in Valsalva, supine weightlifting, and Olympic weightlifting during pregnancy.

Pelvic floor disorders are common in both female athletes and pregnant individuals.(10, 13) It has been hypothesized that increased intra-abdominal pressure from lifting heavy weights, combined with the Valsalva maneuver during pregnancy may further strain the potential weakening of the pelvic floor in pregnancy, increasing the risk of developing or worsening pelvic floor issues. Although we saw heightened prevalence of postpartum UI among the sample (57%), compared to the general population (32%),(28) this is expected of active females who participate in high-impact resistance training (41%),(29) . Further, we did not observe any differences in training patterns during or following pregnancy compared to those who remained continent following childbirth. Similarly, participation in Valsalva during pregnancy was not associated with greater odds of UI during or following pregnancy, suggesting that the increased

intra-abdominal pressure from Valsalva during pregnancy may not increase risk of UI. However, the development of UI can be impacted by a variety of factors including training age, high impact training (e.g., running), and obesity may have influenced these results. Further research is required to assess the impact of weightlifting prior-to pregnancy and the resultant effects on the pelvic floor during and following pregnancy.

Our data demonstrate that the majority of respondents discussed heavy weightlifting during pregnancy with their healthcare provider and were most often told to continue with modification. These results demonstrate pregnant individuals want to know more about heavy weightlifting during pregnancy, aligning with recent requests from elite athletes for more guidance to continue training during pregnancy.(30) More research is critically needed to inform healthcare provider guidance to support individuals who do not wish to cease their training during pregnancy. Approximately half of participants reported seeing a pelvic floor physiotherapist, most commonly in the postpartum period. A review demonstrated that pelvic floor muscle training during pregnancy significantly reduced symptoms and episodes of UI and decreased prevalence in late pregnancy and 3 months postpartum.(31) Increased guidance from pelvic floor physiotherapists may be particularly helpful to this population to help reduce the risk of and treat UI following pregnancy.

Strength and Limitations

Strengths of our study included measurement of reproductive outcomes during and following pregnancy to assess both gestational and postpartum impact of participation in heavy weightlifting. A survey method allowed for the polling of a large sample size of pregnant individuals from around the world who participated in heavy weightlifting improving generalizability of our findings. We also acknowledge important considerations of the present study. Due to the online nature of the study and primary recruitment strategy using social media

platforms, random sampling did not occur thus introducing a sampling bias that may have contributed to some of our findings As well, as this was a cross-sectional survey study with self-reported outcomes, recall bias will have been introduced in this study. Thus, results from this survey should be interpreted with consideration of these limitations. Future longitudinal studies assessing the acute and chronic effects of heavy resistance training in those who engaged in these activities prior to pregnancy compared to those who discontinued training are needed.

This cross-sectional survey did not identify evidence of adverse pregnancy or delivery outcomes by engaging in heavy weightlifting, Olympic weightlifting, Valsalva maneuver, or supine weightlifting during pregnancy. In fact, lower prevalence of common perinatal complications in pregnant and postpartum individuals was observed, with those who continued participation until delivery experiencing fewer complications than those who did not. Our findings demonstrate incidence of postpartum UI was heightened among our sample compared to general population, however, this is expectant of active females who participate in high-impact resistance training. Collectively, these data challenge numerous theoretical risks of participation in resistance training during pregnancy and establish preliminary safety of Olympic weightlifting, Valsalva maneuver, and supine weightlifting during pregnancy. It is important to note that all survey participants were experienced in heavy resistance training during pregnancy, and the impact of the uninitiated beginning these activities during pregnancy is unknown. These data highlight the critical need for more data to help establish the safety and potential benefit of resistance training during pregnancy to challenge persistent myths and improve prescription of these activities during pregnancy. Additional longitudinal work evaluating the long-term impact of heavy resistance training on pelvic floor health are warranted.

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