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Research

# Pregnant women maintain body temperatures within safe limits during moderate-intensity aqua-aerobic classes conducted in pools heated up to 33 degrees Celsius: an observational study

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KEY WORDS

Pregnancy
Exercise
Temperature
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Water temperature

ABSTRACT

**Question:** What is the body temperature response of healthy pregnant women exercising at moderate intensity in an aqua-aerobics class where the water temperature is in the range of 28 to 33 degrees Celsius, as typically found in community swimming pools? **Design:** An observational study. **Participants:** One hundred and nine women in the second and third trimester of pregnancy who were enrolled in a standardised aqua-aerobics class. **Outcome measures:** Tympanic temperature was measured at rest pre-immersion (T1), after 35 minutes of moderate-intensity aqua-aerobic exercise (T2), after a further 10 minutes of light exercise while still in the water (T3) and finally on departure from the facility (T4). The range of water temperatures in seven indoor community pools was 28.8 to 33.4 degrees Celsius. **Results:** Body temperature increased by a mean of 0.16 degrees Celsius (SD 0.35, $p < 0.001$) at T2, was maintained at this level at T3 and had returned to pre-immersion resting values at T4. Regression analysis demonstrated that the temperature response was not related to the water temperature (T2 $r = -0.01$, $p = 0.9$; T3 $r = -0.02$, $p = 0.9$; T4 $r = 0.03$, $p = 0.8$). Analysis of variance demonstrated no difference in body temperature response between participants when grouped in the cooler, medium and warmer water temperatures (T2 $F = 0.94$, $p = 0.40$; T3 $F = 0.93$, $p = 0.40$; T4 $F = 0.70$, $p = 0.50$). **Conclusions:** Healthy pregnant women maintain body temperatures within safe limits during moderate-intensity aqua-aerobic exercise conducted in pools heated up to 33 degrees Celsius. The study provides evidence to inform guidelines for safe water temperatures for aqua-aerobic exercise during pregnancy. **[Brearley AL, Sherburn M, Galea MP, Clarke SJ, (2015) Pregnant women maintain body temperatures within safe limits during moderate-intensity aqua-aerobic classes conducted in pools heated up to 33 degrees Celsius: an observational study. *Journal of Physiotherapy* 61: 199–203]**



## Introduction

Obstetric guidelines for exercise during pregnancy recommend that pregnant women participate in regular moderate-intensity physical exercise.[1–3] They consistently advise not to overheat during exercise due to the potential for foetal harm.[2–4]

Many pregnant women choose to exercise in water, either swimming or participating in aqua-aerobics classes. There are a number of benefits of doing so, including the low-impact effects of buoyancy and the significant beneficial effects on the cardiovascular system due to hydrostatic pressure.[5] Another benefit is that water is an excellent conductor of heat, having 25 times the conductivity rate of air, and is thus an excellent dissipater of exercise-induced body heat if the heat gradient is adequate.[6] Pool water temperature could therefore have a direct effect on whether overheating will occur during an aqua-aerobics session.

Water temperatures between 33 and 37 °C have been termed thermoneutral in a non-exercising healthy person.[7,8] The value may be toward the lower end of these temperatures in a pregnant woman because of the insulating effect of increased fat storage during pregnancy.[5] During exercise, the thermoneutral value of water may alter due to endogenous heat production and vary with the intensity and duration of the exercise. The thermoneutral temperature for moderate-intensity swimming or aerobic exercise in water is reported to be 30 °C.[9] This temperature is considered to be an appropriate temperature for pregnant women doing aerobic exercise in the pool.[5]

When medical bodies have written guidelines for exercise in pregnancy, they consistently warn against overheating; however, only two give a value for the upper limit of water temperature and these have been inconsistent. The 2003 guidelines of the Royal Australian and New Zealand College of Obstetricians and Gynaecologists[10] stated that pregnant women must not exercise in water above 28 °C, but the current guidelines have no recommended value for water temperature.[3] The current British guidelines from the Royal College of Obstetricians and Gynaecologists state that water temperature for aqua classes in pregnancy should not exceed 32 °C.[2] The American College of Obstetricians

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and Gynecologists has not provided a recommended value for water temperature for exercise during pregnancy.[1]

To date, there is little evidence in the literature for the safe upper limit of pool water temperature for pre-natal exercise. The aim of this study was to examine body temperature response of pregnant women engaged in an aqua-aerobics program in community swimming pools, which are normally heated between 28 and 33 °C. Such information would provide empirical evidence that may help to support or inform guidelines for water temperature in aerobic exercise during pregnancy.

Therefore, the research question for this observational study was:

What is the body temperature response of healthy pregnant women exercising at moderate intensity in an aqua-aerobics class where the water temperature is 28 to 33 °C?

## Method

### *Design*

This observational study measured the body temperature changes in pregnant women before, during and after an aqua-aerobics class. The classes involved moderate-intensity exercise in water at the temperatures currently maintained in community pools.

### *Participants, therapists and centres*

Healthy, pregnant women in their second and third trimester of pregnancy who were already enrolled in a pre-natal aqua-aerobics program were invited to participate in the study. The women had already received signed medical clearance from their obstetrician or midwife and had no medical condition or pregnancy complications that would deem them unfit to undertake aerobic exercise. Each participant was measured on one occasion only.

Women who were limited in their capacity to exercise because of musculoskeletal conditions or multiple pregnancies were excluded. Other exclusion criteria were: fever, high blood pressure and potential pre-eclampsia, an open wound, local infection, an allergy to chlorine, feeling unwell on the day, and ruptured membranes (due to risk of bacterial infection). Women in their first trimester of pregnancy were not admitted to the aqua-aerobics program due to class size limitations and the benefits of buoyancy being greater once body shape changes.

For standardisation, one therapist researcher led all aqua-aerobics classes and undertook all measurements. The researcher and participants were blinded as to pool water temperature, which was measured at the end of the exercise session.

Measurements took place at seven indoor community pools over a period of 18 weeks. The pools were chlorinated according to the regulations set by the Victorian Health Department. Pool depths ranged from 0.7 to 2.2 metres.

### *Intervention*

The aqua-aerobics program consisted of a standardised exercise routine and choreography, which was led by the physiotherapist. The 45-minute class included a 35-minute moderate-intensity aerobic workout, which was choreographed to motivating contemporary music of 130 beats per minute, and consisted of warm-up, cardio-fitness exercises, resisted exercises, mobilisation exercises and deep-water exercise without rest periods. The participants were asked to exercise at mid-sternum depth. Standard aquatic equipment, such as foam water dumbbells and foam noodles, were used for added resistance and flotation. The last 10 minutes of the class consisted of pelvic floor muscle exercises, and an active cool-down with floating and gentle stretching. All participants in the class were asked to work at moderate intensity, that is, 13 on the Borg Rating of Perceived Exertion (RPE) scale,[11] or a metabolic equivalent (MET) of 4. Women who were taking part in the study were asked to keep their head well out of the water and not to get their ears wet. Participants consumed water ad libitum, but were encouraged to do so while still moving.

### *Outcome measures*

Body temperature was measured with an infrared, tympanic, electronic thermometer[a]. Water temperature and air temperature were measured with a handheld resistance thermometer[b]. Humidity was measured with a hygrometer[c].

Upon arrival at the pool, each participant was asked to sit quietly to read and sign an informed consent form and then to read the Borg RPE Scale. The Borg RPE Scale has been found to be useful for physical exercise prescription for pregnant women in their last gestational trimester, both in water and on land, especially when exercise is performed at moderate intensity.[11] It is recommended for monitoring exercise intensity in pregnancy in preference to heart rate, which is considered unreliable.[12] Having attended previous aqua-aerobics classes, participants were already familiar with the concept of moderate-intensity exercise.

Tympanic temperature was measured from the right ear with the tympanic thermometer[a] set on 'ear' mode. It was measured four times: Time 1 (T1) – prior to entering the pool after sitting quietly for 15 minutes; Time 2 (T2) – after exercising in the pool for 35 minutes; Time 3 (T3) – at the end of the 45-minute class before exiting from the water; and Time 4 (T4) – prior to leaving the facility after showering and dressing.

Perceived exertion was recorded at T2. If the tympanic temperature was found to be $>$ 1.5 °C above the resting temperature (the safe upper limit for maternal core temperature rise reported in the pregnancy literature[13–15]), or if the participant looked flushed or felt uncomfortably warm or hot, she was asked to cease exercising.

### *Data analysis*

The sample size required to detect a 0.5 °C change in body temperature after exercise was based on a pilot study (unpublished) where tympanic temperature change was measured in 20 students before and after cycling. From this study and consideration of the clinical group of interest, a standard deviation of the change in temperature in the order of 1.5 °C was assumed (repeated measures design, mean difference in pre-exercise and post-exercise temperature). Using an alpha of 0.05 and a power of 0.8, the sample size was calculated to be 73. The actual sample size was increased to at least 100 in order to ensure a minimum number of participants in the sub-sets of pool temperatures that were to be compared.

Regression analysis was used to examine patterns in the data, with water temperature being the independent variable and the change in tympanic temperature being the dependent variable. The covariates, air temperature and humidity were adjusted for by multiple regression analysis. The participants were also grouped according to water temperature categories: Group 1 – participants exercising in water temperature between 28.8 and 30.0 °C; Group 2 – participants exercising in water temperature between 30.1 and 32.0 °C; Group 3 – participants exercising in water temperature between 32.1 and 33.4 °C. Analysis of variance was used to compare the groups in terms of body temperature. A result was considered statistically significant if the $p$-value was $< 0.05$.

## Results

Three hundred and thirteen women in the second or third trimester of pregnancy attended the aqua-aerobics classes over the study period. One hundred and fourteen women volunteered to participate in the study and two of these did not meet the inclusion criteria. Three participants were excluded from the analysis as water was splashed into their ears. Therefore, the data from

**Table 1**
Demographic data of participants.

| Characteristic | n = 109 |
|---|---|
| Age *(yr)*, mean (SD) range | 32 (4) 24 to 42 |
| Parity *(n)*, mean (SD) range | 1.2 (0.4) 1 to 3 |
| Gestational age *(wk)*, mean (SD) range | 29 (6) 15 to 39 |
| Resting body temp *(°C)*, mean (SD) range | 36.5 (0.4) 35.4 to 37.5 |
| Amount of physical activity, n (%) | |
| no regular exercise before or during pregnancy | 2 (2) |
| light exercise 2 to 3/wk or irregularly | 4 (4) |
| light-to-moderate-intensity exercise usually 3/wk | 86 (79) |
| moderate-intensity exercise ≥ 3/wk, high pre-pregnancy fitness | 12 (11) |
| daily moderate intensity exercise, very high pre-pregnancy fitness[a] | 4 (4) |

[a] For example, marathon runner, elite athlete.

109 participants were analysed: 24 in Group 1, 73 in Group 2, and 12 in Group 3. The descriptive data are presented in Table 1.

There was a significant mean increase in temperature of 0.16 °C after 35 minutes of exercise (T2), which was maintained at the end of the class while participants were still in the pool (T3). By the time the participants were dressed and ready to leave, the mean temperature had dropped back to resting levels (T4). The maximum increase in temperature recorded was 1.2 °C and this occurred at T2 in one participant (water temperature 30.2 °C, perceived exertion 13) and in one participant at T3 (water temperature 31.7 °C, perceived exertion at T2 was 13). At no time did body temperature increase in any individual woman by the threshold amount considered to be dangerous to the foetus: 1.5 °C above resting body temperature. The upper limits of the 95% CIs also did not exceed this threshold. The maximum tympanic temperature recorded was 37.5 °C at T1, 37.7 °C at T2, 37.5 °C at T3 and 37.4 °C at T4. Each of these temperatures was measured from a different participant. None of the women needed to stop exercising due to perception of uncomfortable body heat. The results are reported in Table 2.

Regression analysis was used to determine whether a relationship existed between the water temperature, which ranged between 28.8 and 33.4 °C, and the change in tympanic temperature at the three time points T2, T3 and T4. Change in body temperature was plotted against water temperature at the three time intervals (Figure 1). Regression equations were formulated to find the line of best fit. The resulting regression lines showed that there was no relationship between the participants' change in body temperature and the water temperature in which they were exercising. Pearson correlation coefficients ($r$) were not significant at any time point.

Because women are immersed to xiphisternal level for much of an aqua-aerobics class, air temperature and environmental humidity may have an effect on thermoregulation and body temperature. Even after adjusting for these covariates by multiple regression analysis, any change in body temperature was not influenced by water temperature ($p > 0.97$ for T2 minus T1, $p = 0.9$ for T3 minus T1, $p = 0.6$ for T4 minus T1).

Water temperature influence was studied in greater detail by dividing the cohort into three water temperature groups. Demographic data, environmental humidity and air temperature were similar in the three groups. The Borg RPE at T2 was 13 (SD 1) in Group 1, 13 (SD 1) in Group 2, and 13 (SD 1) in Group 3. A one-way analysis of variance was used to compare the change in body temperature in the three water temperature categories at the three time intervals. This analysis showed that the water temperature was not associated with the changes in body temperature. The results are reported in Tables 3 and 4. (See Table 5 on the eAddenda for individual participant data).

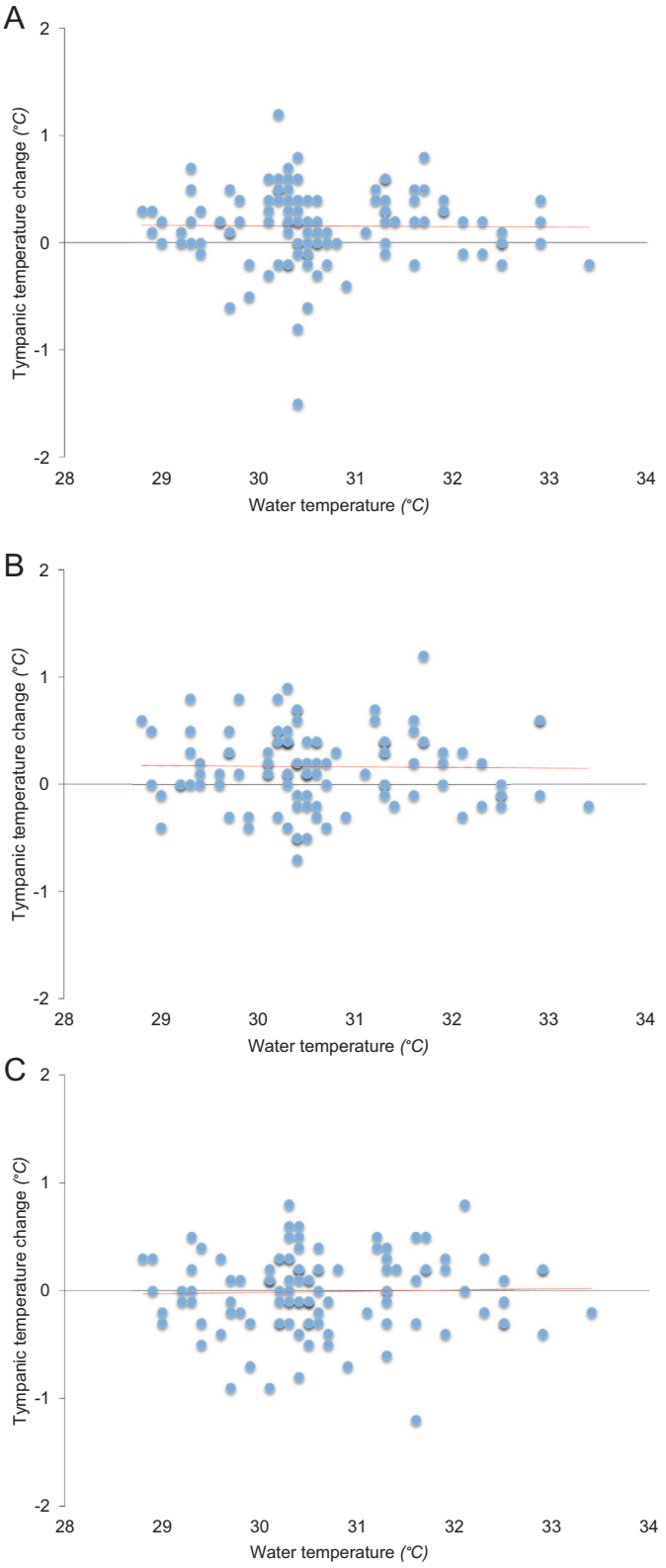


**Figure 1.** Scatterplots of absolute changes in tympanic temperature against water temperature at the three time points with regression lines.
**A.** T2 minus T1, which is the change from initial resting temperature after 35 minutes of moderate-intensity aerobic exercise in pool ($r = -0.01$, $p = 0.9$).
**B.** T3 minus T1, which is the change from initial resting temperature at the end of 45-minute class before exiting the water ($r = -0.02$, $p = 0.9$).
**C.** T4 minus T1, which is the change from initial resting temperature at point of leaving facility after dressing ($r = 0.03$, $p = 0.8$).

## Discussion

The study found that there was a significant small increase in body temperature (mean 0.16 °C) after 35 minutes of moderate-intensity aerobic exercise in swimming pools with water heated between 28.8 and 33.4 °C. This increase in body temperature was maintained during a further 10 minutes of immersion and gentle exercise. Body temperature returned to pre-immersion resting levels by the time the

**Table 2**
Results of a one-sample *t*-test examining change in tympanic temperature from baseline (T1) to the three subsequent time points in the study.

| Time period | n | Temperature change (°C) | | | | | *t* | *p*-value |
|---|---|---|---|---|---|---|---|---|
| | | mean | SD | min | max | 95% CI | | |
| T2 minus T1 | 109 | 0.16 | 0.35 | −1.5 | 1.2 | 0.09 to 0.22 | 4.57 | < 0.001 |
| T3 minus T1 | 109 | 0.16 | 0.35 | −0.7 | 1.2 | 0.10 to 0.24 | 4.9 | < 0.001 |
| T4 minus T1 | 109 | −0.01 | 0.36 | −1.2 | 0.8 | −0.08 to 0.06 | −0.29 | 0.8 |

**Table 3**
Changes in tympanic temperature in the three temperature categories at the three time intervals.

| Time period | Group | n | Temperature change (°C) | | | |
|---|---|---|---|---|---|---|
| | | | mean | SD | min | max |
| T2 minus T1 | 1 | 24 | 0.13 | 0.29 | −0.6 | 0.7 |
| | 2 | 73 | 0.18 | 0.39 | −1.5 | 1.2 |
| | 3 | 12 | 0.04 | 0.18 | −0.2 | 0.4 |
| T3 minus T1 | 1 | 24 | 0.15 | 0.34 | −0.4 | 0.8 |
| | 2 | 73 | 0.19 | 0.36 | −0.7 | 1.2 |
| | 3 | 12 | 0.04 | 0.31 | −0.3 | 0.6 |
| T4 minus T1 | 1 | 24 | −0.09 | 0.34 | −0.9 | 0.5 |
| | 2 | 73 | 0.01 | 0.37 | −1.2 | 0.8 |
| | 3 | 12 | 0.01 | 0.34 | −0.4 | 0.8 |

Group 1 = participants exercising in water between 28.8 and 30.0 °C.
Group 2 = participants exercising in water between 30.1 and 32.0 °C.
Group 3 = participants exercising in water between 32.1 and 33.4 °C.

participants were dressed and ready to leave the facility. The temperature of the water was found to have no association with the body temperature response. Air temperature and humidity were also found to have no association with the body temperature response. When the effect of water temperature was examined more closely by dividing the cohort into three groups based on water temperature (cooler water, mid-range and warmer water), there was no difference in body temperature response. At no time did body temperatures rise to the level of the 1.5 °C limit in any individual woman and on no occasion did a woman report that she felt too hot and needed to stop exercising.

The mean rise in body temperature of 0.16 °C was similar to that found in other pregnancy water-exercise studies. McMurray and colleagues[9] found a mean increase of 0.2 °C after 20 minutes of cycling in water on a modified ergometer at moderate intensity in women during the 25th to 26th gestational week, where the water temperature was 30 °C. A study by Katz and colleagues[16] measured rectal temperatures after 20 minutes of moderate-intensity cycling in women at various gestational ages and found no changes from initial resting land temperatures in water heated to 30 °C. However, the women in this study had been immersed in water for 20 minutes before the exercise began, which caused a decrease in body temperature. In a study by Borjesson-Dunlap and colleagues,[17] 12 second-trimester women undertook 50 minutes of moderate-intensity aerobic exercise, after which their rectal temperatures increased by 0.35 °C in cooler water (27.7 °C) and by 0.39 °C in warmer water (33.5 °C). This is a valuable study as it is the only study, to date, that has examined the effect of different pool temperatures on the body temperature response to aqua-exercise in pregnant women. However, it has been published only in abstract form.

In the present cohort of pregnant women, temperatures remained elevated above initial land values for the 10 minutes after the aerobic component of the class had ceased and while the participants were still in the water performing gentle mobility exercises, pelvic floor exercises and muscle stretches. This lag in temperature response was expected.[18] Harvey and colleagues[19] described a lag in temperature restabilisation in women after immersion in hot tubs.

When the present cohort was divided into three groups according to water temperature, an analysis of variance found no difference in the body temperature response between the three groups. While there was no trend towards higher body temperature in the group exercising in the warmest water, this group contributed the least data. The results from the group exercising in the warmer water may be explained by the water still being cool enough to dissipate heat away from the body, which indicates that thermoregulatory mechanisms are active in these water temperatures. Another explanation may be that this group could have been employing behavioural thermoregulation,[20] subconsciously exercising at a slightly lower intensity than the other groups while still reporting perceived exertion of 13 on the Borg RPE scale. This scale was used instead of a heart rate monitor because heart rate is not a reliable indicator of exercise intensity during pregnancy as it varies with gestational age.[12] In aquatic exercise, this is further complicated by the effect of hydrostatic pressure, which causes a decrease in heart rate due to an increase in stroke volume.[5] As community pools may be heated above 32 °C, further investigation in water temperatures above 32 °C is warranted. While the sub-group of women exercising in the warmest water temperatures was too small to make strong conclusions about the safety of exercising in this temperature, it provides preliminary evidence that concurs with the findings of Borjesson-Dunlap et al,[17] which suggested that aerobic exercise in water temperatures up to 33 °C is unlikely to lead to unacceptable pregnant body temperature rises.

**Table 4**
Pairwise differences between groups in change in tympanic temperature at the three time intervals.

| Time period | Overall test | Pairwise comparisons | | | *p*-value |
|---|---|---|---|---|---|
| | | Comparison | Change in temperature (°C) | | |
| | | | Mean difference | 95% CI | |
| T2 minus T1 | F(2, 106) = 0.94, *p* = 0.4 | Group 2 minus Group 1 | 0.06 | −0.14 to 0.26 | 0.8 |
| | | Group 3 minus Group 1 | −0.08 | −0.38 to 0.21 | 0.8 |
| | | Group 3 minus Group 2 | −0.14 | −0.40 to 0.12 | 0.4 |
| T3 minus T1 | F(2, 106) = 0.93, *p* = 0.4 | Group 2 minus Group 1 | 0.04 | −0.16 to 0.23 | 0.9 |
| | | Group 3 minus Group 1 | −0.11 | −0.40 to 0.18 | 0.7 |
| | | Group 3 minus Group 2 | −0.15 | −0.40 to 0.11 | 0.4 |
| T4 minus T1 | F(2, 106) = 0.70, *p* = 0.5 | Group 2 minus Group 1 | 0.10 | −0.10 to 0.30 | 0.5 |
| | | Group 3 minus Group 1 | 0.10 | −0.21 to 0.40 | 0.7 |
| | | Group 3 minus Group 2 | −0.00 | −0.27 to 0.26 | > 0.95 |

Group 1 = participants exercising in water between 28.8 and 30.0 °C.
Group 2 = participants exercising in water between 30.1 and 32.0 °C.
Group 3 = participants exercising in water between 32.1 and 33.4 °C.

There was much individual variation found in body temperature response to aqua-aerobics. The individual variations may be the result of numerous factors, which include differences in: basal metabolic rates, basal temperatures, thermoneutrality values, subcutaneous fat, gestational age, exercise intensity capacity, fitness levels, pre-pregnancy training, hydration levels and motivation. It appears that temperature responses to moderate-intensity exercise in these water temperatures are more likely to be based on individual variations in thermoregulation rather than variations in the water temperature. Further investigation is needed to determine the potential for hyperthermia in morbidly obese pregnant women and in those who are sedentary.

A limitation of this study was that true core temperature was not measured, as this can only be performed by invasive means. Rectal temperature, the accepted gold standard of near-core measurement in the clinical situation, was not appropriate for this study as measurements needed to be taken in a public group setting and while the women were still immersed in the water. Ingestibles, such as telemetric pills, which measure intestinal temperature, are not appropriate in a pregnancy population. Tympanic temperature has been shown to have a strong correlation with rectal temperature in both hospital[21] and exercise situations[22,23] and importantly in tracking rectal temperature response during exercise.[22,23] While the actual measure is not the same (tympanic temperature is known to be 1 °C lower than core temperature and 1.16 °C lower than rectal temperature), it was the change in temperature that was important in this study, not the actual temperature.

The pregnancy literature reports that the safe upper limit for maternal core temperature is 38.9 °C,[9,24] or 1.5 °C above resting core temperature.[13–15] While both of these values are important, the focus of the present study was the change in temperature from the resting temperature and we chose to observe the 1.5 °C increase as the temperature threshold. Furthermore, as this study examined the body temperature response to exercise in varying water temperatures, the change in temperature was more meaningful.

This is the first study to examine the response of body temperature in pregnant women who are engaged in aqua-aerobic exercise in a real-life context in community swimming pools that are heated between 28 °C and 33 °C. It is the largest study to examine the pregnant body temperature response to aerobic exercise in water that is heated to 33 °C. The data that were obtained support the British guidelines for water temperature, which state that water temperatures up to 32 °C are safe for aerobic exercise in pregnancy. Furthermore, the study suggests that water temperatures up to 33 °C are unlikely to lead to unacceptable rises in pregnant body temperature. The study has provided previously lacking evidence to inform guidelines for safe water temperatures for aqua-aerobic exercise during pregnancy.

**What is already known on this topic**: Moderate-intensity exercise is beneficial for pregnant women, but overheating during exercise may harm the foetus. Many pregnant women participate in aerobic exercise classes in heated pools, but current guidelines are unclear about appropriate pool temperatures.

**What this study adds**: Healthy pregnant women maintain body temperatures within safe limits during moderate-intensity aqua-aerobic exercise conducted in pools heated up to 33 °C. Within the range of 28 to 33 °C, the pool temperature does not appear to influence the slight rise in body temperature that occurs during moderate-intensity aqua-aerobic exercises.

***Footnotes***: [a] Genius 2, Tyco Healthcare Group, Mansfield, USA. [b] Center 370-PT100 RTD Thermometer, Center Technology Corporation, Taipei, Taiwan. [c] Lutron Hygrometer, Model HT-3009, Instrument Choice, Regency Park, Australia.

***eAddenda***: Table 5 can be found online at doi:10.1016/j.jphys.2015.08.004

***Ethics approval***: The University of Melbourne Human Research Ethics Committee approved this study (ID 0827521). All participants gave written informed consent before data collection began.

***Competing interests***: Nil.

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