Oocytes, obesity, and omega-3 fatty acids

Fatty acids are vital dietary sources of energy for humans and are also important structural components of cells. The well-known omega-3 fatty acids, also known as n-3 fatty acids, are not made in enough quantities in the body and therefore need to be acquired from dietary sources making them essential fatty acids. In general, n-3 fatty acids have been shown to improve conditions such as psychiatric disease, heart disease, metabolic syndrome, ADHD, fetal brain development, autoimmune disease, and cancer.

With an increasing obesity epidemic, dietary consumption of fatty acids is at the forefront of various research investigations (1). Recent studies have shown possible roles of fatty acids in human reproduction. Fatty acid concentrations in follicular fluid surrounding the oocyte have been analyzed by a number of studies showing that elevated fatty acid levels were associated with poor cumulus oocyte complex morphology and poor response to ovarian stimulation (1, 2). However, the role of n-3 fatty acids in human oocytes is poorly understood. The study by Matorras et al. (3) is the first to look at fatty acid composition in human oocytes to the best of our knowledge. This is a timely topic as we are in the midst of an obesity epidemic and various investigations have shown that obesity impacts all facets of health including fertility, and specifically assisted reproductive technology outcomes.

In this study, the authors looked at 205 women who were undergoing in vitro fertilization, grouped them based on body mass index, and evaluated their oocyte fatty acid profiles. They analyzed oocytes from metaphase I, metaphase II, and germinal vesicle stages using capillary gas chromatography. They evaluated a total of 922 oocytes and analyzed them in batches in 9 groups. Their results show that women who were obese had lower levels of saturated fatty acids and polyunsaturated n-3 fatty acids across all studied stages of oocyte development, and overweight women had lower n-3 fatty acids in metaphase II oocytes. Given that n-3 fatty acids are essential in embryo development not only neurologically but also at the cell signaling level, this could account for some of the poorer outcomes seen in overweight and obese women undergoing in vitro fertilization. Further, it is interesting to note that the n-3 fatty acid docosahexaenoic acid was highest in obese patients while eicosapentaenoic acid was lowest. The authors found that obesity did not necessarily associate with the levels of fatty acids as expected in a unhealthier western diet. Therefore, it is important to further evaluate dietary choices and their impact on oocyte fatty acid composition and not just use body mass index as a surrogate.

It is interesting that the authors bring up the Barker hypothesis in their discussion. Recent studies in animal models showed that obesity induced by high fat diets affected skeletal muscles and cardio-metabolic health across multiple generations (1, 4). Currently, we do not know the role of different fatty acids and their impact on reproduction. Could obesity and specifically dietary composition of fatty acids also impact oocyte quality across multiple generations? Will these diet alterations result in epigenetic changes affecting reproduction in multiple generations, and can we preempt these changes? These are important future questions to explore. Given that lipids, and especially polyunsaturated fatty acids are essential for embryo and fetal development this study by Matorras and colleagues (3) is of great importance. They have now identified that the impact of fatty acids starts from the oocyte stage onwards.

Another aspect to consider is the role of fatty acids in oocyte and embryo cryopreservation (5). Although the mechanism is not understood, it is well known that high lipid contents makes cryopreservation difficult in both oocytes and embryos causing cryo-damage. The fatty acid contents of human oocytes have successfully been quantified and profiled in this study. Although oocyte vitrification in humans is a refined and highly successful process, it is not known if differential fatty acid content affects the success rates of oocyte and embryo cryopreservation and therefore if dietary intake can affect vitrification and warming. If diet does indeed play a role in oocyte fatty acid composition, important next steps would be to evaluate in animal models how this translates to reproductive outcomes including cryopreservation. This could then be translated to human studies of dietary fatty acid composition/ratio and its role in fertility.

Omega-3 fatty acids are considered essential fatty acids as they cannot be synthesized in our bodies but can only be obtained from dietary sources. They are involved in various structural and functional aspects of the cell membrane. They are essential for cell to cell communication, nutrient import and export, gene regulation etc. A well-balanced diet containing these fatty acids is essential and now this study suggests that fatty acids may even influence oocyte quality. The role of fatty acids and especially the impact of dietary composition of n-3 fatty acids in fertility is yet to be discovered.

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