IVYSPRING INTERNATIONAL PUBLISHER

Journal of Genomics

2013; 1:1-4. doi: 10.7150/jgen.3276

Editorial

Adipogenesis: It Is Not Just Lipid That Comprises Adipose Tissue

Michael V. Dodson[1]✉, Zhihua Jiang[1], Min Du[1] and Gary J. Hausman[2]

1. Department of Animal Sciences, Washington State University, Pullman, WA 99164, USA
2. USDA-ARS, Richard B. Russell Agricultural Research Station, Athens, GA 30604, USA

✉ Corresponding author: Dr. M.V. Dodson, Department of Animal Sciences, Washington State University, Pullman, WA 99164; Tel: +1 509-335-9644; FAX: +1 509 335 1082; E-mail: dodson@wsu.edu

Published: 2013.10.01

Abstract

Adipogenesis is the initial component of forming cells (adipocytes) capable of assimilating lipid. Lipid metabolism is a metabolic process whereby lipid is stored for use when energy is required. Both processes involve cellular and molecular components. The gene regulations of each are different and (yet) confusingly, markers for both are used interchangeably. The focus of this paper is to provide elementary information regarding both processes and to introduce this issue of *Journal of Genomics*, whereby important aspects of adipogenesis and lipid metabolism involving gene expression are provided.

Key words: Adipogenesis, Lipid Metabolism, Gene Regulation

The total amount of adipose tissue, or fat, that a person or animal possesses tells a story about their lives [1-3]. Species, gender, age and health condition are clearly correlated with total adipose load of the body [4-7]. In general, a high body fat load suggests that a person over eats, or consumes a disproportionate level of energy, without a compensating level of exercise [8,9]. In animals, especially meat animals, a high percentage of body fat commonly means that the overall content of lean meat will be reduced [8,10-14]. The physiology and end-effects of whole body adipose load is important and has been recently reviewed [1-3,7,8,10-14]. While one might think that adipose tissue is the same regardless of anatomical locale, it is not [8,11,12,15]. Different adipose tissue depots exist in humans and in animals, and the regulation of these fat deposits appear to be different [8,11,15-27]. Moreover, some adipose tissue depots possess ability to synthesize and release into the systemic circulation whole-body regulators possessing numerous physiology changing signals [11,28]. Due to this, attention has been given to elucidating adipose-depot-specific capability to regulate other aspects of body physiology [10,11]. Differences and influences of different adipose tissue depots have been introduced by papers within this issue. Moreover, if one were to look closely at the structural make-up of a small portion of any adipose tissue depot it would be readily apparent that the tissue is composed of important structures that might play a role in the regulation of the depot [11,29-30]. Blood supply, extracellular components and proportion of different cells all contribute to the overall physiology of any adipose tissue. Histology of adipose tissue has been recently reviewed [29-31].

A wide variety of cells exist in association with adipose tissue [8,11,14,17,29-30]. Lipid-containing cells called adipocytes may be white or brown [11,14,29,32]. Cells committed to the adipose lineage, but not filled with lipid termed preadipocytes/adipofibroblasts also exist and are reported to be capable of providing new cells to the adipose tissue depot if needed for energy storage [11,17,29,33]. Other cell types such as a variety of blood-type cells exist in

adipose tissue [11,29-30]. The mechanism(s) through which all cells of the adipose tissue work together to make the tissue function remain unknown. Moreover, the regulation exerted on individual cells to other cells is also unknown.

Adipogenesis is the process of forming lipid-assimilating adipocytes from cells committed to doing so, whereas lipid metabolism is the process of accepting lipid, storing it, and releasing it from an adipocyte [1-3,11,12,34-39]. Usually, one thinks of adipogenesis occurring during late fetal development, and into early adolescence. However, it may occur at any time throughout the lifetime of the person/animal [1,7,8,11]. Lipid metabolism occurs continuously, but has been highlighted in humans as something that leads to obesity and the adverse health effects of possessing too much lipid metabolism that leads to excess lipid stores [1,7,8,11]. A variety of protein markers have been identified that are associated with both adipogenesis and lipid metabolism [12,13,40]. These markers have been discerned through the use of both cell lines and primary cultures of cells derived from different animals [11,14,29]. Blood tests and associated metabolic panels have been devised utilizing some of these markers to inform humans about potential problems associated with variables of lipid health [41]. Usefulness of cell line identified markers to other (specific) animal model systems is being explored [3,12,13].

Traditional cell biology principals suggest that once a cell has been committed to a specific lineage and begins to express the lineage-specific markers of differentiation that the cell is terminally differentiated--possessing no further capabilities to exhibit primordial phenotypes [34-37,40,42-46]. In the case of adipocytes, traditional thought is that once any cell begins to assimilate lipid into vesicles (undergoes lipid metabolism) that the cell no longer possesses the ability to proliferate (undergo adipogenesis). Recent reports suggest that this just does not hold true for (even) mature adipocytes [8,11,17,34-37,40,42-46]. As such, cells provided by the dedifferentiation of mature adipocytes to form proliferative-competent progeny cells needs to be explored as potential mechanisms of additional adipogenesis/lipid metabolism [8,11,12,17,19,23,34-39,42-45]. Moreover, such cells may actually provide for a relatively new source of cells for tissue regenerative/reconstruction measures/procedures and other uses of potential stem cells [42,43].

The physical presence of genes and the expression of genes are two different processes that need to be explored in the realm of adipogenesis and lipid metabolism [3,11,12,24-26,32,38,47-48]. Are there specific gene products that can be exploited to help regulate adipogenesis and/or lipid metabolism? Are these easily expressed as detectable markers, whereby one might use them as diagnostic tools? Are all animals genetically regulated similarly in terms of adipogenesis/lipid metabolism? The contributions of this issue of the *Journal of Genomics* add to our knowledge of important aspects of adipogenesis and lipid metabolism.

Conflict of Interest

The authors have declared that no conflict of interest exists.

References

1. Bergen WG, Mersmann HJ. Comparative aspects of lipid metabolism: Impact on contemporary research and use of animal models. Journal of Nutrition 2005 135:2499-2502
2. Hill R, Dunshea F, Dodson MV. Growth of Livestock. In: Scanes CG, ed. Biology of Growth of Domestic Animals; Chapter 18. UK: Blackwell Publishers. 2003: 342-364
3. Calza RE, Dodson MV. Approaches to Assess Animal Growth Potential. In: Scanes CG, ed. Biology of Growth of Domestic Animals; Chapter 4. UK: Blackwell Publishers. 2003: 27-58
4. Geer EB, Shen W. Gender differences in insulin resistance, body composition, and energy balance. Gender Medicine 2009 6: 60-75
5. Cooke PS, Naaz A. Role of estrogens in adipocyte development and function. Experimental Biology and Medicine 2004 229:1127-1135
6. Williams CM. Lipid metabolism in women. Proceedings of the Nutrition Society 2004 63:153-160
7. Dodson MV, Mir PS, Hausman GJ, Guan LL, Du M, Jiang Z, Fernyhough ME, Bergen WG. Obesity, metabolic syndromes and adipocytes. Journal of Lipids 2011;2011:721686
8. Dodson MV, Hausman GJ, Guan LL, Du M, Rasmussen TP, Poulos SP, Mir P, Bergen WG, Fernyhough ME, McFarland DC, Rhoads RP, Soret B, Reecy JM, Velleman SG, Jiang Z. Lipid metabolism, adipocyte depot physiology and utilization of meat animals as experimental models for metabolic research. International Journal of Biological Sciences 2010 6(7):691-699
9. Lee M-J, Wu Y, Fried SK. Adipose tissue remodeling in pathophysiology of obesity. Current Opinion Clinical Nutrition Metabolic Care 2010 13:371-376
10. Dodson MV, Jiang Z, Chen J, Hausman GJ, Guan LL, Novakofski J, Thompson D, Lorenzen C, Fernyhough ME, Mir P, Reecy J. Allied industry approaches to alter intramuscular fat content and composition in beef animals. Journal of Food Science 2010 75:R1-8
11. Hausman GJ, Dodson MV, Ajuwon K, Azain M, Barnes K, Guan LL, Jiang Z, Poulos SP, Sainz RD, Smith S, Spurlock M, Novakofski J, Fernyhough ME, Bergen WG. Board Invited Review: The biology and regulation of preadipocytes and adipocytes in meat animals. Journal of Animal Science 2009 87:1218-1246
12. Basu U, Guan LL, Taniguchi M, Zhao Y, Dodson MV. Application of 'omics' technologies on improvement of meat quality in livestock species. In: Nutritional Biochemistry: Genomics, Metabolomics and Food Supply; Chapter 4. Hauppauge, NY: Nova Science Publishers, Inc. 2009.
13. Prokesch A, Hackl H, Hakim-Weber R, Bornstein SR, Trajanoski Z. Novel insights into adipogenesis from omics data. Current Medicinal Chemistry 2009 16:2952-2964

14. Novakofski J. Adipogenesis: Usefulness of in vitro and in vivo experimental models. Journal of Animal Science 2004 82:905-915
15. Cartwright MJ, Tchkonia T, Kirkland JL. Aging in adipocytes: Potential impact of inherent, depot-specific mechanisms. Experimental Gerontology 2007 42:463-471
16. Smith SB, Kawachi H, Choi CB, Choi CW, Wu G, Sawyer JE. Cellular regulation of bovine intramuscular adipose tissue development and composition. Journal of Animal Science 2009 87:E72-82
17. Dodson MV, Hausman GJ, Guan LL, Du M, Rasmussen TP, Poulos SP, Mir P, Bergen WG, Fernyhough ME, McFarland DC, Rhoads RP, Soret B, Reecy JM, Velleman SG, Jiang Z. Skeletal muscle stem cells from animals I. Basic cell biology. International Journal of Biological Sciences 2010 6(5):465-474
18. Dodson MV, Vierck JL, Hausman GJ, Guan LL, Fernyhough ME, Poulos SP, Mir P, Jiang Z. Examination of adipose depot-specific PPAR moieties. Biochemical Biophysical Research Communications 2010 349:241-242
19. Chen J, Dodson MV, Jiang Z. Cellular and molecular comparison of redifferentiation of intramuscular- and visceral-adipocyte derived progeny cells. International Journal of Biological Sciences 2010 6(1):80-88
20. Jin W, Dodson MV, Moore SS, Basarb JA, Guan LL. Characterization of microRNA expression in bovine subcutaneous fat tissues: A potential regulatory mechanism of subcutaneous adipose tissue development. BMC Molecular Biology 2010 11:29-37
21. Zhao YM, Basu U, Zhou M, Dodson MV, Basarb JA, Guan LL. Proteome analysis of subcutaneous fat tissues from beef cattle with different backfat thickness and breeds. Proteome Science 2010 8:14-24
22. Wang X, Xue C, Wang X, Liu H, Xu Y, Zhao R, Jiang Z, Dodson MV, Chen J. Differential display of expressed genes reveals a novel function of SFRS18 in regulation of intramuscular fat deposition. International Journal of Biological Sciences 2009 5(1):28-33
23. Fernyhough ME, Hausman GJ, Dodson MV. Progeny from dedifferentiated adipocytes display protracted adipogenesis. Cells, Tissues, Organs 2008 188:359-372
24. Taniguchi M, Guan LL, Zhang B, Dodson MV, Okine E, Moore SS. Gene expression patterns of bovine perimuscular adipocytes during adipogenesis. Biochemical Biophysical Research Communications 2008 366:346-351
25. Taniguchi M, Guan LL, Zhang B, Dodson MV, Okine E, Moore SS. Adipogenesis of bovine perimuscular adipocytes. Biochemical Biophysical Research Communications 2008 366:54-59
26. Taniguchi M, Guan LL, Basarab J, Dodson MV, Moore SS. Comparative analysis of gene expression profiles in subcutaneous fat tissues of beef cattle. Comparative Biochemistry and Physiology 2008 3(4):251-256
27. Sepe A, Tchkonia T, Thomou T, Zamboni M. Aging and regional differences in fat cell progenitors-A mini review. Gerontology 2011 57:66-75
28. Hauner H. Secretory factors from human adipose tissue and their functional role. Proceedings Nutrition Society 2005 64:163-169
29. Poulos SP, Dodson MV, Hausman GJ. Cell line models of preadipocytes and adipocytes. Experimental Biology and Medicine 2010 235:1185-1193
30. Hausman GJ, Richardson RL. Adipose tissue angiogenesis. Journal of Animal Science 2004 82:925-934
31. Mariman ECM, Wang P. Adipocyte extracellular matrix composition, dynamics and role in obesity. Cellular Molecular Life Science 2010 67:1127-1292
32. White U, Stephens JM. Transcriptional factors that promote formation of white adipose tissue. Molecular Cellular Endocrinology 2010 318:10-14
33. Laudes M. Role of WNT signalling in the determination of human mesenchymal stem cells into preadipocytes. Journal Molecular Endocrinology 2011 46:R65-72
34. Dodson MV, Fernyhough ME, Vierck JL, Hausman GJ. Adipocytes may not be a terminally differentiated cell type: Implications for animal production. Animal Science 2005 80(3):239-240
35. Fernyhough ME, Helterline DI, Vierck JL, Hausman GJ, Hill RA, Dodson MV. Dedifferentiation of mature adipocytes to form adipofibroblasts: More than a possibility. Adipocytes 2005 1(1):17-24
36. Fernyhough ME, Vierck JL, Dodson MV. Assessing a non-traditional view of adipogenesis: adipocyte dedifferentiation – mountains or molehills? Cells, Tissues, Organs 2006 182(3-4):226-228
37. Fernyhough ME, Bucci L, Hausman GJ, Antonio J, Vierck JL, Dodson MV. Gaining a Solid Grip on Adipogenesis. Tissue and Cell 2005 37(4):335-338
38. Chen J, Guridi M, Fernyhough ME, Jiang Z, Guan LL, Hausman GJ, Dodson MV. Clonal mature adipocyte production of proliferative-competent daughter cells requires lipid export prior to cell division. International Journal of Stem Cells 2009 2:76-79
39. Chen J, Guridi M, Fernyhough ME, Jiang Z, Guan LL, Hausman GJ, Dodson MV. Initial differences in lipid processing leading to pig- and beef-derived mature adipocyte dedifferentiation. Basic and Applied Myology (European Journal of Translational Myology) 2009 19(5):243-246
40. Kokta T, Dodson MV, Gertler A, Hill RA. Review: Intercellular signaling between adipose tissue and muscle tissue. Domestic Animal Endocrinology 2004 27(4):303-331
41. Brown JD, Plutzky J. Peroxisome proliferator-activated receptors as transcriptional nodal points and therapeutic targets. Circulation 2011 115:518-533
42. Dodson MV, Fernyhough ME. Mature adipocytes: Are there still novel things that we can learn from them? Tissue & Cell 2008 40:307-308
43. Fernyhough ME, Hausman GJ, Guan LL, Okine E, Moore SS, Dodson MV. Mature adipocytes may be a source of stem cells for tissue engineering. Biochemical Biophysical Research Communications 2008 368(3):455-457
44. Dodson MV, Hausman GJ, Guan LL, Du M, Jiang Z. Potential impact of mature adipocyte dedifferentiation in terms of cell numbers. International Journal of Stem Cells 2011 4:76-78
45. Fernyhough ME, Vierck JL, Hausman GJ, Mir PS, Okine EK, Dodson MV. Primary adipocyte culture: adipocyte purification methods may lead to a new understanding of adipose tissue growth and development. Cytotechnology 2004 46:163-172
46. Fernyhough ME, Okine E, Hausman GJ, Vierck JL, Dodson MV. Invited review: PPAR-gamma and GLUT-4 expression as differentiation markers for preadipocyte conversion to become an adipocyte. Domestic Animal Endocrinology 2007 33:367-378
47. Romao JM, Jin W, Dodson MV, Hausman GJ, Moore SS, Guan LL. MicroRNA regulation of mammalian adipogenesis. Exp Biol Med (Maywood). 2011 Sep;236(9):997-1004
48. Du M, Dodson MV. Advanced techniques to enhance marbling in meat. Control of Meat Quality (Joo S, ed). 2011

Author Biography

Dr. Michael V. Dodson is a Professor in the Animal Sciences Department at Washington State University (WSU), and affiliate faculty of the Center for Integrated Biotechnology (WSU) and Washington Center for Muscle Biology (collective effort between

WSU and the University of Washington). For nearly three decades Dr. Dodson has studied skeletal muscle-derived stem cells. This work has resulted in nearly 150 papers on new methods for satellite cell- and adipocyte-derived stem cell isolation, culture, analysis and interpretation. Dr. Dodson has supported team research for his entire career, including a variety of efforts related to the USDA-sponsored research projects: NC1131 Molecular mechanisms regulating skeletal muscle growth and differentiation and NCCC201 Regulation of adipose tissue accretion in meat-producing animals (NCR97).

Dr. Zhihua Jiang is an Associate Professor in the Animal Sciences Department at Washington State University. Since the early 1990's, Dr. Jiang's research has focused on comparative genome biology with aims at understanding how orthologous genes have evolved and shuffled during evolution. The overall objective of his research program is to develop comparative genomic tools and reagents for determining gene sequence, location, expression and function, thus advancing genome sciences and their applications in agriculture and biomedicine. Dr. Jiang has published more than 110 publications that were well cited in the field. He was editor of the book "Reproductive Genomics in Domestic Animals" Published by Wiley-Blackwell in 2010. Dr. Jiang has received eight US patent awards.

Dr. Min Du was an associate professor in the Department of Animal Science at University of Wyoming and has recently moved to the Animal Sciences Department at Washington State University as a Professor and Funded Chair in Animal Sciences. His research focuses on the physiological conditions regulating skeletal muscle growth and development, and mechanisms governing differentiation of mesenchymal stem cells into myocytes, adipocytes and fibroblasts during fetal development. He has been publishing actively and currently serving as reviewers for a number of funding agencies and journals.

Dr. Gary J. Hausman has authored or co-authored nearly 200 scientific articles published in refereed journals, and have given a multitude of invited presentations at national and international scientific meetings. Dr. Hausman's research reputation is reflected in invitations to present and discuss research data and requests to consult with colleagues in academia, in industry, and in other governmental institutions throughout the world. In addition, he has conceived, planned and organized major symposia for the national American Society of Animal Science and the Experimental Biology Meetings. Dr. Hausman has also served on an NIH grant review panel and several committees that impact Agency, Departmental and Congressional policy makers.