Acta fytotechn zootechn, 27, 2024(4): 366-378
http://www.acta.fapz.uniag.sk

Original Paper

Changes in Anthropometric Parameters Due to the Consumption of Full-fat Sheep Milk Yogurt Depending on Visceral Fat Area

Martina Gažarová[1*], Jana Kopčeková[1], Petra Lenártová[1], Róbert Toman[2]

[1] *Slovak University of Agriculture in Nitra, Faculty of Agrobiology and Food Resources, Institute of Nutrition and Genomics, Nitra, Slovak Republic*
[2] *Slovak University of Agriculture in Nitra, Faculty of Agrobiology and Food Resources, Institute of Animal Husbandry, Nitra, Slovak Republic*

Article Details

Received: 2024-07-19 | Accepted: 2024-10-07 | Available online: 2024-12-31

https://doi.org/10.15414/afz.2024.27.04.366-378

Yogurt is considered a functional food, either in terms of the content of specific nutrients or thanks to its probiotic and other health-promoting properties. The aim of the work was to assess changes in selected anthropometric parameters related to the risk of obesity after six weeks of consumption of full-fat yogurt made from sheep's milk, depending on the pre-intervention visceral fat area (under or over 100 cm^2) in twenty female participants. Significant differences were found between the groups in all anthropometric parameters ($P < 0.05$). The group of women with over-limit values of VFA had higher values of all parameters. However, pre-post intervention differences and changes within groups were non-significant ($P > 0.05$). We found that the consumption of full-fat yogurt did not significantly affect the body composition of either consumer with optimal values of visceral fat area or participants with above-limit values of visceral adipose tissue. No worsening of the monitored parameters was confirmed in any of the groups. In this context, we can recommend the consumption of yogurt with a natural fat content and made from sheep's milk for moderate consumption to all types of consumers.

Keywords: visceral fat, anthropometric, obesity, health, yogurt, sheep

1 Introduction

As statistics and surveys show, the consumption of milk and milk products has been on the rise in Slovakia recently. Over the past five years, it has risen from 171.1 kg per person per year to 184.8 kg (Sitárová, 2023). The number of proven positive health effects and awareness mainly contribute to this. The results of the survey by Gažarová et al. (2022b) show that milk and milk products are still a full-fledged part of the diet of the Slovak population, thanks to which we can ensure the satisfaction of nutritional needs in terms of the intake of important nutritional components, including iodine. However, the consumption of fermented milk products is decreasing in the Slovak population. Since 2018, consumption has dropped from 16.8 kg per person per year to 13.7 kg (Sitárová, 2023). This trend clearly needs to be reversed.

Yogurt is generally considered an excellent source of quality protein, calcium, potassium and B vitamins (Shah, 2007). It is a long-recognized dairy food commodity available in different textures, with different fat content and flavours (Fazilah et al., 2018). Yogurt consumption is associated with improved lactose metabolism, exhibits antimutagenic, anticarcinogenic and antihypertensive properties, has a positive effect on diarrheal diseases, stimulates the immune system and alleviates the symptoms of inflammatory bowel diseases (Shakerian et al., 2015). The number of studies describing the importance of various nutrients and bioactive compounds in dairy products is constantly increasing. In most European countries, the consumption of yoghurts made from cow's milk dominates. A study by Vargas-Bello-Pérez et al. (2022) points out that 74% of the respondents

---

[*] **Corresponding Author:** Martina Gažarová. Slovak University of Agriculture in Nitra, Faculty of Agrobiology and Food Resources, Institute of Nutrition and Genomics, Tr. A. Hlinku 2, 949 76, Nitra, Slovakia. E-mail: martina.gazarova@uniag.sk. ORCID: https://orcid.org/0000-0001-8275-7311

declared that they regularly consume dairy products made from the milk of small ruminants, i.e. sheep and goats.

The stated frequency was 1 to 2 times a week. The authors of the study found that consumers from Mediterranean countries prefer sheep's milk products over goat's milk products, with more than 50% of respondents considering them healthy.

For the production of yogurt, sheep's milk is an ideal input substrate due to its high protein content and total dry matter content. It has a different texture, it is creamier (Balthazar et al., 2017). Compared to cow's milk, it has a higher content of minerals, vitamins and fat (Raynal-Ljutovac et al., 2008). Sheep's milk is characterized by higher concentrations of short- and medium-chain fatty acids (Raynal-Ljutovac et al., 2008; Vagenas and Roussis, 2012). Of the polyunsaturated fatty acids, linoleic and α-linolenic acid, as well as their isomers, are represented here (Recio et al., 2009). Sheep milk fat contains one of the highest concentrations of conjugated linoleic acid (0.65 g per 100 g fatty acids; Revilla et al., 2017). Mono- and polyunsaturated fatty acids in sheep's milk may contribute to the prevention of cardiovascular diseases due to their antiatherogenic and antithrombogenic effects (Balthazar et al., 2016). Short-chain fatty acids have been found to have no detrimental effect on blood cholesterol concentrations (Huth and Park, 2012) and are harmless in terms of inflammation (Visioli and Strata, 2014). Drouin-Chartier et al. (2016) based on their research found that the harmful consequences of consuming saturated fat from dairy products such as cheese, yogurt and others can be eliminated if they are part of complex food matrices. The results of the study by Gažarová et al. (2023b) indicate that the consumption of full-fat sheep's yogurt does not cause health complications and deterioration of the lipid profile, inflammatory or anthropometric parameters in terms of fat content. Studies suggest that the health risks of saturated fat must be assessed comprehensively and not individually. A growing body of evidence suggests that postprandial responses are strongly influenced by the food matrix (Thorning et al., 2017).

In relation to adiposity, consumption of milk and dairy products during adolescence showed a neutral or reduced health risk (Dror, 2014). Similarly, the results of the meta-analysis of Lu et al. (2016) and Wang et al. (2016) showed that dairy intake was associated with a reduced risk of obesity and reduced body fat in children. Based on current knowledge, the consumption of full-fat dairy products is no longer associated with obesity or excessive weight gain, but rather with the formation of fat-free and active mass in the body (Gažarová et al., 2021).

Adipose tissue was previously considered an energy reservoir, but it is now clear that it has an active role in systemic metabolism through the active secretion of adipokines and obesogenic hormones (Gustafson et al., 2007; Hiuge-Shimizu et al., 2012). Adipose tissue is a metabolically active endocrine organ. It is categorized into two main types as white adipose tissue, which stores energy in the form of triglycerides, and brown adipose tissue, which is responsible for the release of energy during cold exposure (so-called thermogenesis; Cannon and Nedergaard, 2004). White adipose tissue forms the majority of adipose tissue in adults and is found mainly in subcutaneous areas and around internal organs (visceral adipose tissue). The storage of fat in visceral depots makes obese individuals more susceptible to health complications. It is evident that excessive visceral fat deposition is a key phenotype associated with a cluster of metabolic abnormalities, including hypertension, atherogenic dyslipidaemia, and impaired glucose tolerance (Després, 2012).

Visceral fat has a more significant negative impact on health than subcutaneous fat because it is more biologically active, has a higher cell density, distributes more blood and is located near the portal vein, resulting in an increased concentration of fatty acids that reach the liver (Matsuzawa et al., 1995). Recent evidence from 2022 shows that the negative health effects of obesity come not only from excess fat, but also from a decrease in its ability to respond to change (Sakers et al., 2022). If adipose tissue cannot perform its normal storage and liporegulatory function, this can lead to the development of metabolic deregulation with resulting insulin resistance and its cardiometabolic consequences (Unger and Scherer, 2010). Visceral obesity increases cardiovascular risk by strengthening direct (dyslipidemia, hypertension and hyperglycemia) but also indirect mechanisms. Adipose tissue dysfunction causes an atherogenic pattern of secretion of adipokines, proinflammatory cytokines, prothrombotic and vasoactive factors (van Gaal et al., 2006; Klöting and Blüher, 2014).

The aim of the work was to assess changes in selected anthropometric parameters related to body composition and the risk of obesity after six weeks of consumption of full-fat yogurt made from sheep's milk, depending on the pre-intervention values of visceral fat area.

2 Material and methods

2.1 Characteristics of the participants and study design

The study was performed in accordance with the guidelines of the Declaration of Helsinki and approved by the ethics committee (study protocol no. 031219_2019). Twenty women (aged 40-67 years) involved in the study expressed written consent to the terms of the study. The principle of the study consisted in the daily consumption of full-fat yogurt made from sheep's milk for six weeks. The compositions of the yogurt, as well as the methodical procedure, were described in more detail in Gažarová et al. (2023b). For the purposes of this study, we divided the group of women according to the pre-intervention values of the visceral fat area. This resulted in two groups of women, a group with a visceral fat area below 100 cm^2 (7 participants) and a group of women with a visceral fat area above 100 cm^2 (13 participants). We evaluated the average energy intake from food, as well as the intake of macronutrients and iodine using the software Mountberry – Nutrition & Fitness Software (2011; Wellberry, s.r.o., Tuchyňa, Slovak Republic).

2.2 Anthropometric parameters

Methodological details regarding anthropometric measurement are given in the previous publication Gažarová et al. (2023b). The principle of body composition assessment consisted in using the method of multi-frequency bioelectrical impedance analysis (MFBIA) using the device InBody 720 (Biospace Co. Ltd., Seoul, Korea). As part of the assessment of body composition, we focused on circumference and mass parameters, muscle, fat and fat-free mass, as well as index parameters derived from them (Skrzypczak et al., 2007; WHO, 2008; 2020; DAPA, 2024). A VFA value of 100 cm^2 (Biospace Co. Ltd., Seoul, Korea) was used as the key determinant and cut-off value of visceral fat area.

2.3 Statistical analysis

We used MS Office (Los Angeles, CA, USA) and XLSTAT to process the input data. For statistical evaluation, we used the STATISTICA 13 program (TIBCO Software, Inc., Palo Alto, CA, USA), specifically one-factor analysis of variance (ANOVA) and Fisher's post hoc test. The level of significance was set at $P < 0.05$.

3 Results and discussion

The key parameter for assessing changes due to the intervention was the area of visceral fat in the participants at the beginning of the study. Based on the input data, the study group was divided into two subgroups. The first group consisted of female volunteers whose VFA values did not exceed the critical value of 100 cm^2. It consisted of women aged 49.43±5.5 years, ranging from 40 to 56 years. The second group consisted of women with initial VFA values above 100 cm^2 with an average age of 56.77±7.5 years, ranging from 45 to 67 years. Detailed descriptive information is presented in Table 1. We found significant differences between the groups in the case of age, basal metabolic rate, body condition status, as well as in total energy intake and carbohydrate intake. The group of women with over-limit VFA values was older, with a higher basal metabolic rate but not body condition status, and overall a higher intake of energy, carbohydrates, fats and iodine, with the exception of proteins. For women of this age, according to the Recommended Nutrition Doses for Population of the Slovak Republic (Kajaba et al., 2015), the optimal energy intake is 8800 kJ, proteins 57 g, fats 72 g and carbohydrates 306 g. According to the above, women with lower VFA values had insufficient intake of energy and carbohydrates. Women with higher VFA values had energy and nutritional intake above the limit on average.

Table 2 shows pre-post intervention values and changes in anthropometric parameters depending on the distribution of women according to the initial VFA values. A six-week intervention consisting of daily consumption of full-fat yogurt made from sheep's milk had no significant effect on the anthropometric parameters of any of the studied groups ($P > 0.05$). However, significant differences were found between the groups in all anthropometric parameters, with the exception of the ratio of total body water and fat-free mass, not only at the beginning of the study, but also after its completion. The group of women with over-limit values of VFA had all the anthropometric parameters examined higher.

Table 1 Baseline characteristics of the study groups

		VFA <100 cm^2 (n = 7)				*VFA >100 cm^2 (n = 13)*				***P*-value**
Parameters	**Units**	**Mean**	**±SD**	**Min**	**Max**	**Mean**	**±SD**	**Min**	**Max**	
Age	years	49.43	5.50	40	56	56.77	7.50	45	67	***<0.05***
Height	cm	165	5.37	158	174	166	4.60	160	173	ns
BMR	kcal	1,352	54	1,278	1,435	1,490	82	1,398	1,618	***<0.001***
Body condition status	points	74.00	4.65	65.00	80.00	64.15	6.53	52.00	75.00	***<0.01***
Intake per day										
Energy	kJ	7,669	1,365	3,735	9,468	11,111	3,409	7,258	17,553	***<0.05***
Carbohydrates	g	207	87	91	297	311	114	148	522	***<0.05***
Fats	g	80.50	38.32	28	122	99.39	29.43	36.70	129	ns
Proteins	g	79.80	18.69	30	105	77.35	14.99	52.70	102	ns
Iodine	µg	158.48	86.32	95.90	283	161.03	79.34	52.30	305	ns

Data are expressed as mean ± standard deviation. ns – non-significant difference

Table 2 Pre-post intervention changes within and between groups

			VFA <100 cm^2					**VFA >100 cm^2**					
Parameters	**Units**	**Pre-post**	**Mean**	**±SD**	**Min**	**Max**	***P*-value**	**Mean**	**±SD**	**Min**	**Max**	***P*-value**	***Inter-group P-value***
Weight	kg	day 0	65.50	3.28	61.10	70.80	0.156	89.34	8.22	75.50	100.00	0.842	***<0.001***
		day 42	64.90	3.06	61.80	70.80		89.42	8.80	75.00	103.70		***<0.001***
Fat-free mass	kg	day 0	45.43	2.50	42.00	49.30	0.522	51.84	3.79	47.60	57.80	0.986	***<0.01***
		day 42	45.17	2.77	40.80	49.00		51.83	4.13	46.50	59.40		***<0.01***
Visceral fat area	cm^2	day 0	82.74	8.76	71.75	97.10	0.776	145.12	20.20	111.52	182.54	0.462	***<0.001***
		day 42	82.05	12.23	71.96	107.52		145.89	21.69	108.88	182.37		***<0.001***
Percentage of body fat	%	day 0	30.46	5.25	23.67	40.63	0.780	41.69	4.83	34.74	50.48	0.896	***<0.001***
		day 42	30.22	5.94	24.58	42.30		41.73	5.00	33.92	49.56		***<0.001***
Body fat mass	kg	day 0	20.07	4.36	14.80	28.80	0.600	37.50	7.17	27.10	50.50	0.755	***<0.001***
		day 42	19.73	4.85	15.30	30.00		37.58	7.47	26.80	51.40		***<0.001***
Skeletal muscle mass	kg	day 0	24.90	1.32	23.05	26.93	0.375	28.54	2.41	25.88	32.46	0.854	***<0.01***
		day 42	24.68	1.53	22.17	26.80		28.58	2.59	25.35	33.32		***<0.01***
Waist-to-hip ratio		day 0	0.89	0.03	0.85	0.93	0.604	1.01	0.04	0.94	1.08	0.321	***<0.001***
		day 42	0.89	0.03	0.84	0.92		1.01	0.05	0.92	1.10		***<0.001***
Body mass index	kg.m^{-2}	day 0	24.18	2.16	22.11	28.36	0.169	32.65	4.29	25.66	39.31	0.817	***<0.001***
		day 42	23.96	2.20	21.90	28.36		32.69	4.52	25.35	40.76		***<0.001***
Waist circumference	cm	day 0	85.70	2.37	82.70	90.00	0.225	108.79	8.28	94.20	123.60	0.256	***<0.001***
		day 42	84.80	3.68	80.30	91.10		109.60	9.05	92.20	124.30		***<0.001***
Hip circumference	cm	day 0	95.73	3.43	91.80	102.20	0.228	108.07	5.23	100.10	114.80	0.908	***<0.001***
		day 42	95.34	3.03	92.30	101.60		108.10	5.52	99.90	116.50		***<0.001***
Intra-cellular water	l	day 0	20.63	1.01	19.20	22.20	0.402	23.42	1.84	21.40	26.40	0.901	***<0.01***
		day 42	20.47	1.19	18.50	22.10		23.45	1.97	21.00	27.10		***<0.01***
Extra-cellular water	l	day 0	12.70	0.85	11.60	14.00	0.618	14.60	0.92	13.60	16.10	0.782	***<0.001***
		day 42	12.64	0.87	11.50	13.90		14.56	1.05	13.20	16.30		***<0.001***

Total body water	l	day 0	33.33	1.86	30.80	36.20	0.464	38.02	2.73	35.00	42.10	0.962	***<0.01***
		day 42	33.11	2.04	30.00	36.00		38.01	2.99	34.20	43.40		***<0.01***
Total body water/Fat-free mass	%	day 0	73.36	0.15	73.13	73.53	0.389	73.36	0.22	72.84	73.62	0.631	ns
		day 42	73.31	0.22	72.91	73.53		73.34	0.19	73.03	73.61		ns

Data are expressed as mean ± standard deviation. ns – non-significant difference

As shown in Figure 1, women with optimal VFA values had significantly lower pre-post intervention body weight (65.5±3.28 vs 64.9±3.06 kg, *P* <0.001), fat-free mass (45.43 ±2.50 vs 45.17±2.77 kg, *P* <0.01), body fat mass (20.07±4.36 vs 19.73±4.85 kg, *P* <0.001) and skeletal muscle mass (24.90±1.32 vs 24.68±1.53 kg, *P* <0.01) compared to women with upper limit VFA values, as follows: body weight (89.34±8.22 vs 89, 42±8.80 kg), fat-free mass (51.84±3.79 vs 51.83±4.13 kg), body fat mass (37.50±7.17 vs 37.58±7.47 kg) and skeletal muscle mass (28.54±2.41 vs 28.58±2.59 kg). When assessing body composition, it is necessary to evaluate the share of individual components on body weight, and not just their quantitative amount. As we mentioned, the values of FFM and SMM were significantly higher in the group with a higher proportion of visceral fat. However, when evaluating the proportion of these components of body composition in relation to body weight, it was shown that the values of FFM% and SMM% were significantly higher in the group of women with a lower proportion of visceral fat. Women with optimal VFA had pre-post values of FFM% 69.52±5.26 vs 69.79±5.96% in the range 59.32-76.28 vs 57.63-75.36%; pre-post values of SMM% were 38.11±2.84 vs 38.13±3.29% in the range 32.56-41.76 vs 31.31-41.00%. Women with over-limit VFA had pre-post values of FFM% 58.31±4.84 vs 58.26±5.00% in the range 49.5-65.31 vs 50.43-66.07%; pre-post values of SMM% 32.09±2.9 vs 32.12±2.97% in the range 26.92-36.68 vs 27.5-37.06%. It clearly follows from the above that the proportion of fat-free or muscle mass is higher in women with optimal VFA values, which is also related to higher values of body condition status.

Figure 2 shows pre-post intervention values and changes in visceral fat area, percentage of body fat, waist circumference, body mass index and waist-to-hip ratio in both groups. Even in the case of these parameters, women with optimal VFA values had significantly lower values compared to women with above-limit VFA values, as follows: VFA 82.74±8.76 vs 82.05±12.23 cm^2, *P* <0.001; PBF 30.46±5.25 vs 30.22±5.94%, *P* <0.001; WC 85.70±2.37 vs 84.80±3.68 cm, *P* <0.001; BMI 24.18±2.16 vs 23.96±2.20 $kg.m^{-2}$, *P* <0.001; and WHR 0.89±0.03 vs 0.89±0.03, *P* <0.001. Women with above-limit VFA values had the following values: VFA 145.12±20.20 vs 145.89±21.69 cm^2; PBF 41.69±4.83 vs 41.73±5.00%; WC 108.79±8.28 vs 109.60±9.05 cm; BMI 32.65±4.29 vs 32.69±4.52 $kg.m^{-2}$; and WHR 1.01±0.04 vs 1.01±0.05. We can conclude that women with optimal VFA values only had optimal BMI and WC values. The other parameters were increased, just like the women from the second group, although only slightly.

We were interested in what quantitative changes occurred within groups and individual parameters, and whether these changes differed significantly between groups. In most of the examined parameters, there was a decrease in the group of women with optimal VFA values, but compared to the second group, where the values mainly increased, there were no significant differences (*P* >0.05). Differences in groups are presented in Table 3, and individual differences are expressed in Figure 3.

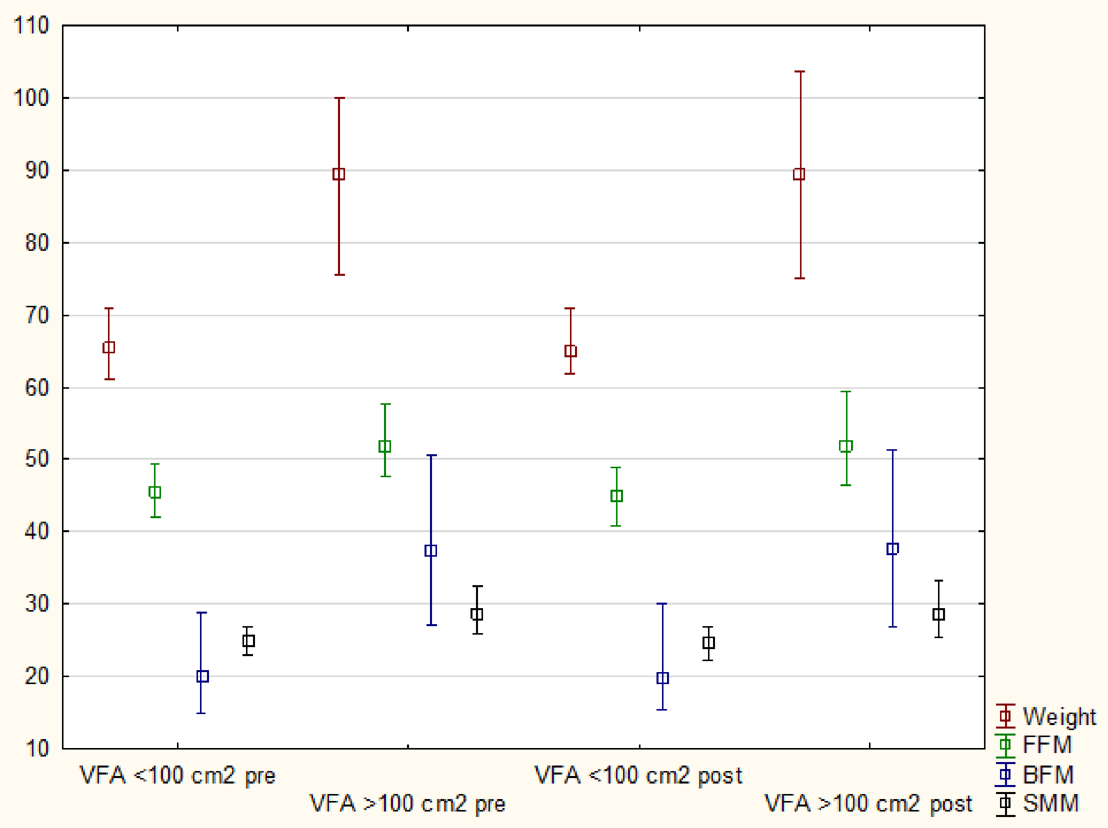

Fig. 1 Pre-post intervention changes of weight, fat-free mass (FFM), body fat mass (BFM), and skeletal muscle mass (SMM)

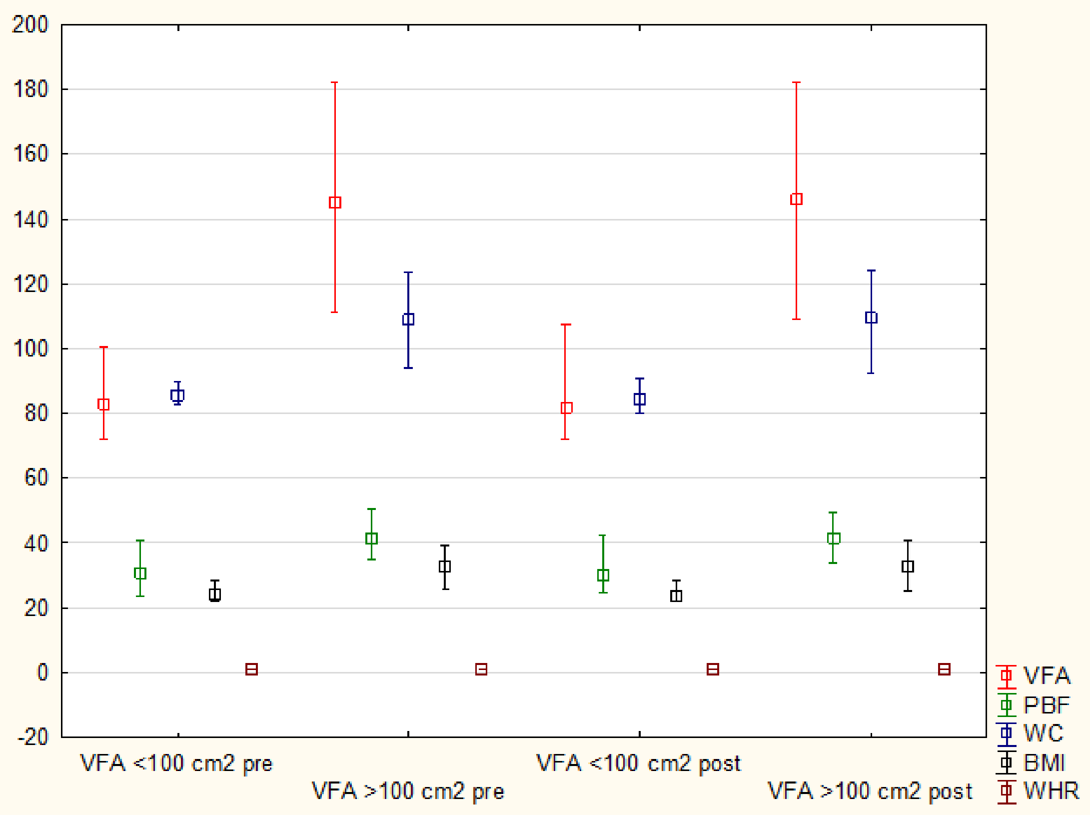

Fig. 2 Pre-post intervention changes of visceral fat area (VFA), percentage of body fat (PBF), waist circumference (WC), body mass index (BMI), and waist-to-height ratio (WHR)

Table 3 Pre-post intervention differences within groups

Parameters	**Units**	**Group**	**Mean**	**±SD**	**Min**	**Max**	***Inter-group P-value***
Weight	kg	VFA <100 cm^2	-0.60	0.98	-2.40	0.70	0.218
		VFA >100 cm^2	0.08	1.36	-1.30	3.70	
Fat-free mass	kg	VFA <100 cm^2	-0.26	1.00	-1.20	1.50	0.665
		VFA >100 cm^2	-0.01	1.52	-2.20	2.80	
Visceral fat area	cm^2	VFA <100 cm^2	-0.68	6.10	-9.51	7.52	0.579
		VFA >100 cm^2	0.77	3.65	-3.25	7.18	
Percentage of body fat	%	VFA <100 cm^2	-0.24	2.17	-3.62	1.83	0.757
		VFA >100 cm^2	0.04	1.15	-2.30	1.59	
Body fat mass	kg	VFA <100 cm^2	-0.34	1.64	-3.10	1.30	0.543
		VFA >100 cm^2	0.08	0.96	-2.30	1.10	
Skeletal muscle mass	kg	VFA <100 cm^2	-0.22	0.61	-0.88	0.79	0.434
		VFA >100 cm^2	0.04	0.86	-1.19	1.60	
Waist-to-hip ratio	-	VFA <100 cm^2	0.00	0.02	-0.04	0.02	0.284
		VFA >100 cm^2	0.01	0.03	-0.03	0.05	
Body mass index	kg.m^{-2}	VFA <100 cm^2	-0.21	0.36	-0.89	0.27	0.227
		VFA >100 cm^2	0.03	0.52	-0.48	1.45	
Waist circumference	cm	VFA <100 cm^2	-0.90	1.76	-2.90	1.20	0.091
		VFA >100 cm^2	0.81	2.44	-2.40	5.00	
Hip circumference	cm	VFA <100 cm^2	-0.39	0.76	-1.70	0.50	0.300
		VFA >100 cm^2	0.03	0.94	-1.00	2.40	
Intra-cellular water	l	VFA <100 cm^2	-0.16	0.46	-0.70	0.60	0.485
		VFA >100 cm^2	0.02	0.66	-0.90	1.20	
Extra-cellular water	l	VFA <100 cm^2	-0.06	0.29	-0.40	0.50	0.916
		VFA >100 cm^2	-0.04	0.49	-0.80	0.90	
Total body water	l	VFA <100 cm^2	-0.21	0.72	-0.90	1.10	0.638
		VFA >100 cm^2	-0.02	1.13	-1.60	2.10	
Total body water / Fat-free mass	%	VFA <100 cm^2	-0.05	0.16	-0.24	0.20	0.635
		VFA >100 cm^2	-0.02	0.15	-0.20	0.23	

Data are expressed as mean ± standard deviation. ns – non-significant difference

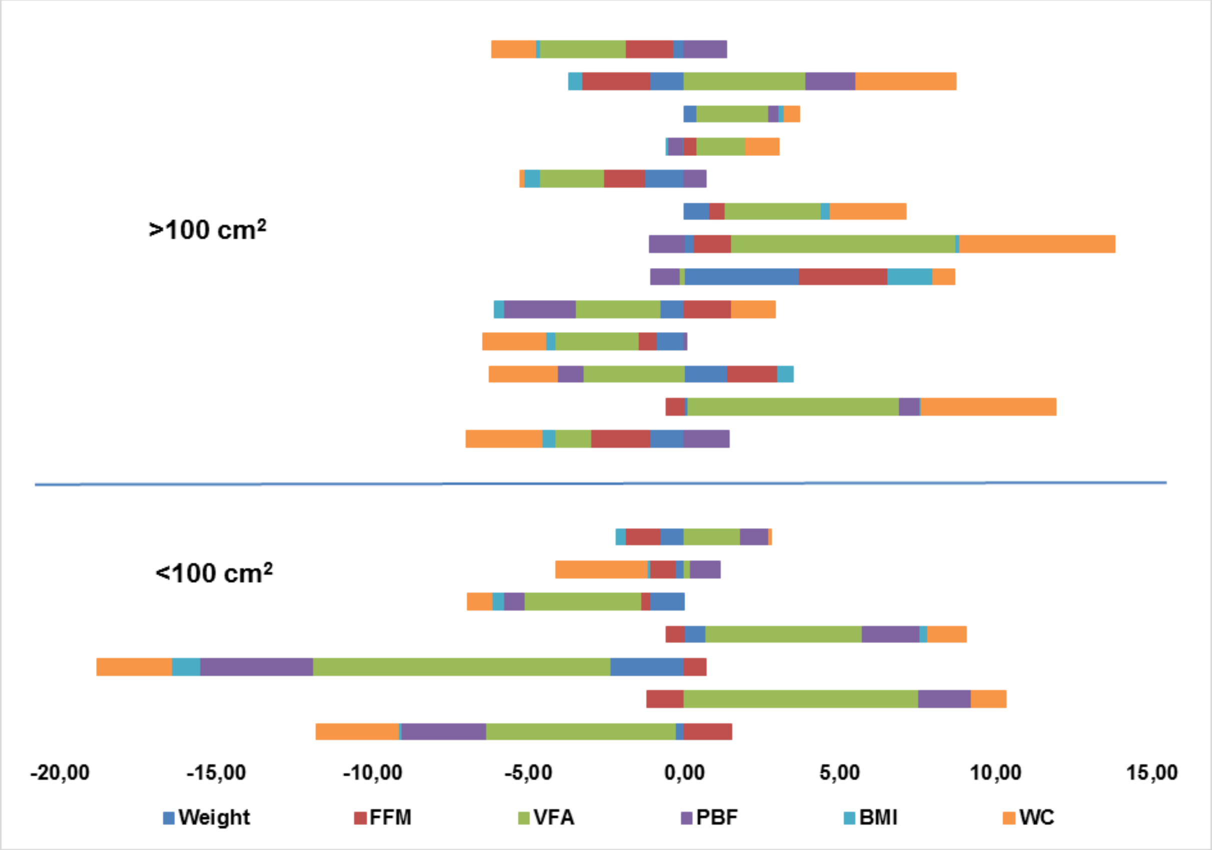

Fig. 3 Individual pre-post intervention differences of specific anthropometric parameters in participants

Data are expressed as follows: weight in kg; fat-free mass (FFM) in kg; visceral fat area (VFA) in cm^2; percentage of body fat (PBF) in %; body mass index (BMI) in kg.m^{-2}; waist circumference (WC) in cm

The results of several studies indicate that, from a longer-term perspective, consumers who limit their milk fat intake have a higher body weight gain than consumers of full-fat dairy products (Kratz et al., 2013; Sayón-Orea et al., 2015). Rautiainen et al. (2016) also reached similar results on a sample of more than eighteen thousand women older than 45 years. Higher frequency of full-fat dairy consumption was associated with lower levels of weight gain in these women. Feeney et al. (2017) found that a higher rate of milk consumption was associated with a reduced body mass index in favour of muscle mass and against body fat. Similar favourable results were reported by Romaguera et al. (2011) and Faghih et al. (2011) in the case of changes in waist circumference and waist-to-hip ratio. A diet with a higher proportion of milk led to a greater decrease in waist circumference and waist-to-hip ratio values. In relation to fat mass, it is assumed that a higher intake of calcium can reduce lipogenesis and increase lipolysis through hormonal regulation (Zemel, 2005), but also affect the absorption of fatty acids from the digestive tract (Vaskonen, 2003). Milk proteins have an insulinotropic effect and support the feeling of satiety (Veldhorst et al., 2008). For this reason, they can be a suitable dietary means for reducing body weight. The consumption of dairy products has recently been associated, among other things, with the reduction of blood pressure and LDL cholesterol, as well as with the prevention of type 2 diabetes (Tunick and Van Hekken, 2015). Gažarová et al. (2023a, 2023b) and Kopčeková et al. (2022) found that the daily consumption of full-fat sheep's or cow's yogurt, as well as full-fat cow's milk, during six weeks did not cause a deterioration of the health status, nor a deterioration of the lipid profile, glucose tolerance, inflammatory and liver markers, or anthropometric parameters.

When predicting various health risks, the assessment of the amount of body fat and its distribution in different areas of the body is of great importance (Mangla et al., 2020). On the one hand, the weight and proportion of adipose tissue are essential components of body composition assessment (Piqueras et al., 2021), on the other hand, the results of studies in different population groups indicate that the negative impact on health and survival is associated not only with an excessive amount of adipose tissue, but primarily with lower muscle mass (Bosy-Westphal and Müller, 2021). An increase in adipose tissue can be accompanied by a loss of muscle mass, which leads to sarcopenia, or sarcopenic obesity (Donini et al., 2022).

There is a direct correlation between body weight and muscle mass. It is related to the anabolic action of the body weight load on the musculoskeletal system. Obese adults have, on average, greater skeletal muscle mass than normal-weight or lean individuals of the same age and sex. These differences are the result of muscle mass anabolism and hypertrophy induced by the burdening effect of higher body weight associated with obesity. In this context, however, attention should be drawn to the findings that the amount and proportion of muscle mass must be strictly distinguished. While the amount of muscle mass increases with the risk of obesity, the proportion of muscle mass in body weight, on the contrary, decreases. Moreover, compared to non-obese individuals, obese individuals have on average a greater total daily energy expenditure related to a higher resting metabolic rate, which correlates with their increased skeletal muscle mass (Gažarová et al., 2022a). These statements are also consistent with our results.

Skeletal muscle mass is the largest organ in an adult. It is a storehouse of free amino acids, which play a key role in various disease states, stress and body defense (Evans, 1997). It participates in the regulation of glucose in the blood and ensures energy expenditure to a considerable extent. Physical inactivity leads to muscle atrophy (Miyazaki et al., 2008). After the age of forty, skeletal muscle declines at a rate of approximately 5% every 10 years, with approximately 30% in the elderly (Rolland et al., 2008). Both the size and number of muscle fibers decrease with increasing age (Reeves et al., 2006). It has been reported that after age 50, muscle mass declines by approximately 1-2% per year, but strength declines by 1.5% per year and accelerates to 3% per year after age 60 (Evans, 1997). These values are higher in sedentary individuals and twice as high in men compared to women (Gallagher et al., 1997).

Body mass index depends on weight contributed by total body mass, including muscle mass, and not just fat mass, as seen in people with a higher proportion of muscle mass (Müller et al., 2016). A high BMI due to greater fat stores is a risk factor for muscle loss in postmenopausal women, as excessive accumulation of fatty acids around muscle fibers can impair muscle function and thereby reduce muscle quality (Rolland et al., 2009). Age-related increases in fat mass generally precede loss of muscle mass (Baumgartner et al., 1998), but the reverse is also true. Loss of muscle mass results in lower physical activity, resulting in reduced energy expenditure, fat gain, and obesity (Rolland et al., 2009).

Indicators of central adiposity are good indicators of visceral adiposity (Lam et al., 2015). Among these indicators, waist circumference is considered the best, presenting an excellent correlation with abdominal adiposity; and subsequently with cardiovascular diseases and type 2 diabetes (Cornier et al., 2011). Visceral adiposity is associated with higher metabolic morbidity and mortality due to higher levels of inflammatory processes compared to adiposity occurring elsewhere in the body (Yu et al., 2019).

In recent years, with the exception of Slovakia and other European countries, a decrease in the consumption of milk and milk products has been observed worldwide, mainly in connection with the increasing age of consumers and the presence of lactase insufficiency, or as a result of environmental factors or alternative methods of nutrition (Leclercq et al., 2009; Quann et al., 2015). Current trends in alternative nutrition and the increased prevalence of health problems related to the consumption of milk and milk products and their specific ingredients result in an increasingly extensive restriction of their inclusion in the diet plan. Consumers avoiding milk and dairy products were driven to this dietary behaviour by fear of the sustainability of dairy food production. Forty-one percent of the respondents perceived the negative impact of such production on the environment. From a health point of view, twenty-five percent of respondents believed that the consumption of dairy products should be avoided in order to limit the intake of saturated fatty acids (Bouga et al., 2018). In the survey Gažarová et al. (2022b), however, it was shown that milk and milk products are still in demand among Slovak consumers, who prefer cow's milk and semi-fat or full-fat milk. In terms of fat content, the respondents prefer those with a minimal degree of processing and with a normal fat content. The menu also includes dairy products, especially hard cheeses, yogurts and other sour milk products, the consumption of which has a decreasing tendency and it is necessary to reverse this trend. The favourable results of several weeks of consumption of full-fat yogurts made from sheep's milk could also contribute to this.

4 Conclusions

The results of our current and previous work confirmed that the daily consumption of full-fat yogurt made from sheep's milk during six weeks did not cause a deterioration in the health status of consumers, whether biochemical, somatic, anthropometric parameters or inflammatory markers were evaluated. Based on the aim of this work, we can state that the consumption of full-fat yogurt did not fundamentally affect anthropometric parameters and body composition in consumers with optimal and above-limit values of visceral adipose tissue. In none of the investigated groups was the deterioration of the observed parameters confirmed. For this reason and in this context, we can recommend the consumption of yogurt with a natural fat content and made from sheep's milk for moderate consumption to all types of consumers.

Acknowledgments

This study was supported by the Slovak Research and Development Agency under the Contracts no. APVV-18-0227 (50%) and no. APVV-22-0206 (30%); the Educational Grant Agency of the Ministry of Education, Science, Research and Sport of the Slovak Republic (KEGA 003SPU-4/2022; 15%); and the Operational Program Integrated Infrastructure within the project: Long-term strategic research of prevention, intervention and mechanisms of obesity and its comorbidities co-financed by the European Regional Development Fund (ITMS: 313011V344; 5%). The authors would like to thank all volunteers participated in this study and all members of the working group.

References

Balthazar, C.F., Conte Júnior, C.A., Moraes, J. et al. (2016). Physicochemical evaluation of sheep milk yogurts containing different levels of inulin. *J Dairy Sci*., 99, 4160-4168.

Balthazar, C.F., Pimentel T.C., Ferrao, L.L. et al. (2017). Sheep Milk: Physicochemical Characteristics and Relevance for Functional Food Development. *Compr Rev Food Sci Food Saf*., 16, 247-262.

Baumgartner, R.N., Koehler, K.M., Gallagher, D., Romero, L., Heymsfield, S.B., et al. (1998). Epidemiology of sarcopenia among the elderly in New Mexico. *Am J Epidemiol.*, 147(8), 755-763. https://doi.org/10.1093/oxfordjournals.aje.a009520

Bosy-Westphal, A., Müller, M.J. (2021). Diagnosis of obesity based on body composition-associated health risks-Time for a change in paradigm. *Obes Rev*., 22 Suppl 2, e13190. doi:10.1111/obr.13190

Bouga, M., Lean, M., Combet, E. (2018). Dairy products as a source of iodine in the UK, and consumers' perceptions. *Proceedings of the Nutrition Society*, 77(OCE2), E30. https://doi.org/10.1017/S0029665118000241

Cannon, B., Nedergaard, J. (2004). Brown adipose tissue: function and physiological significance. *Physiol Rev.*, 84(1), 277-359. https://doi.org/10.1152/physrev.00015.2003

Cornier, M.A., Després, J.P., Davis, N., Grossniklaus, D.A., Klein, S., et al. (2011). Assessing adiposity: a scientific statement from the American Heart Association. *Circulation*., 124(18), 1996-2019. https://doi.org/10.1161/CIR.0b013e318233bc6a

DAPA. Diet, Anthropometry and Physical Activity Measurement Toolkit. (2022). Available online: https://dapa-toolkit.mrc.ac.uk/anthropometry/introduction/anthropometry (accessed on 29 June 2024).

Després, J.P. (2012). Body fat distribution and risk of cardiovascular disease: an update. *Circulation.*,126(10), 1301-1313. https://doi.org/10.1161/CIRCULATIONAHA.111.067264

Donini, L.M., Busetto, L., Bischoff, S.C., Cederholm, T., Ballesteros-Pomar, M.D., Batsis, J. A., et al. (2022). Definition and Diagnostic Criteria for Sarcopenic Obesity: ESPEN and EASO Consensus Statement. *Obes Facts*., 15(3), 321-335. https://doi.org/10.1159/000521241

Dror, D.K. (2014). Dairy consumption and pre-school, school-age and adolescent obesity in developed countries: A systematic review and meta-analysis. *Obesity Reviews*, 15, 6, 516-527. https://doi.org/10.1111/obr.12158

Drouin-Chartier, J.-P., Brassard, D., Tessier-Grenier, M., Côté, J.A., Labonté, M.-È., Desroches, S., Couture, P. and Lamarche, B. (2016). Systematic review of the association between dairy product consumption and risk of cardiovascular-related clinical outcomes. *Adv. Nutr*., 7, 1026-1040.

Evans, W. (1997). Functional and metabolic consequences of sarcopenia. *J Nutr.*, 127(5 Suppl), 998S-1003S. *https://doi.org/10.1093/jn/127.5.998S*

Faghih, S. et al. (2011). Comparison of the effects of cows' milk, fortified soy milk, and calcium supplement on weight and fat loss in premenopausal overweight and obese women. *Nutrition Metabolism & Cardiovascular Disease*, 21(7), 499-503. https://doi.org/10.1016/j.numecd.2009.11.013

Fazilah, N.F., Ariff, A.B., Khayat, M.E. et al. (2018). Influence of probiotics, prebiotics, synbiotics and bioactive phytochemicals on the formulation of functional yogurt. *J. Funct. Foods*., 48, 387-399.

Feeney, E.L. et al. (2017). Patterns of dairy food intake, body composition and markers of metabolic health in Ireland: results from the National Adult Nutrition Survey. *Nutrition & Diabetes*, 7(2), 243. https://doi.org/10.1038/nutd.2016.54

Gallagher, D., Visser, M., De Meersman, R.E., Sepúlveda, D., Baumgartner, R.N., et al. (1997). Appendicular skeletal muscle mass: effects of age, gender, and ethnicity. *J Appl Physiol.*, 83(1), 229-239. https://doi.org/10.1152/jappl.1997.83.1.229

Gažarová, M., Bihari, M., Lorková, M., Lenártová, P., Habánová, M. (2022a). The use of different anthropometric indices to assess the body composition of young women in relation to the incidence of obesity, sarcopenia and the premature mortality risk. *International Journal of Environmental Research and Public Health,* 19, 12449, 19. https://doi.org/10.3390/ijerph191912449

Gažarová, M., Habánová, M., Lenártová, P., Kopčeková, J., Chlebo, P. (2023a). *Vplyv konzumácie mliečnych produktov s obsahom jódu na ukazovatele funkcie štítnej žľazy a vybrané zdravotné parametre.* 1. vyd. Nitra: Slovenská poľnohospodárska univerzita.

Gažarová, M., Lenártová, P., Lorková, M., Bihari, M., Habánová, M., Kopčeková, J. (2022b). Nutritional preferences and consumption of milk and dairy products as important sources of iodine in human nutrition. In *Lenártová, P., Gažarová, M. Výživa - človek - zdravie 2022.* Nitra: Slovenská poľnohospodárska univerzita, 2022, p. 35-44. ISBN 978-80-552-2559-3.

Gažarová, M., Lorková, M., Habánová, M., Holovičová, M., Kopčeková, J., Mrázová, J., Lenártová, P. (2021). Differences between anthropometric variables among young women depending on milk fat content. *Acta fytotechnica et zootechnica,* 24, 3, 243-249. https://doi.org/10.15414/afz.2021.24.03.243-249

Gažarová, M., Toman, R., Lenártová, P., Pšenková, M., Habánová, M., Kopčeková, J., Tančin, V., Almášiová, S. (2023b). The effect of six-week consumption of full-fat yogurt made from the milk of sheep fed with iodine-enriched feed on indicators of thyroid function and selected biochemical and anthropometric parameters. *Acta fytotechnica et zootechnica,* 26, 3, 223-235. https://doi.org/10.15414/afz.2023.26.03.223-235

Gustafson, B., Hammarstedt, A., Andersson, C.X., Smith, U. (2007). Inflamed adipose tissue: a culprit underlying the metabolic syndrome and atherosclerosis. *Arterioscler Thromb Vasc Biol*., 27(11), 2276-2283. https://doi.org/10.1161/ATVBAHA.107.147835

Hiuge-Shimizu, A., Kishida, K., Funahashi, T., Ishizaka, Y., Oka, R., et al. (2012). Absolute value of visceral fat area measured on computed tomography scans and obesity-related cardiovascular risk factors in large-scale Japanese general population (the VACATION-J study). *Ann Med.*, 44(1), 82-92. https://doi.org/10.3109/07853890.2010.526138

Huth, P.J., Park, K.M. (2012). Influence of dairy product and milk fat consumption on cardiovascular disease risk: a review of the evidence. *Adv Nutr*., 3, 266-285.

Klöting, N., Fasshauer, M., Dietrich, A., Kovacs, P., Schön, M.R., et al. (2010). Insulin-sensitive obesity. *Am J Physiol Endocrinol Metab.*, 299(3), E506-E515. https://doi.org/10.1152/ajpendo.00586.2009

Kopčeková, J., Habánová, M., Lenártová, P., Gažarová, M., Chlebo, P., Mrázová, J. (2022). Milk as a source of iodine and the effect of its consumption on the lipid profile in obese cardiology patients. In Toman, R., Pšenková, M. *Toxické a esenciálne prvky v mlieku a mliečnych výrobkoch I.* Nitra: Slovenská poľnohospodárska univerzita, 2022, p. 39-44. ISBN 978-80-552-2543-2.

Kratz, M., Baars, T., Guyenet, S. (2013). The relationship between high-fat dairy consumption and obesity, cardiovascular, and metabolic disease. *European Journal of Nutrition*, 52(1), 1-24. https://doi.org/10.1007/s00394-012-0418-1

Lam, B.C., Koh, G.C., Chen, C., Wong, M.T., Fallows, S.J. (2015). Comparison of Body Mass Index (BMI), Body Adiposity Index (BAI), Waist Circumference (WC), Waist-To-Hip Ratio (WHR) and Waist-To-Height Ratio (WHtR) as predictors of cardiovascular disease risk factors in an adult population in Singapore. *PLoS One.*, 10(4), e0122985. https://doi.org/10.1371/journal.pone.0122985

Leclercq, C., Arcella, D., Piccinelli, R. et al. (2009). The Italian National Food Consumption Survey INRAN-SCAI 2005-06: main results in terms of food consumption. *Public Health Nutr*., 12(12), 2504-2532.

Lu, L., Xun, P., Wan, Y. et al. (2016). Long-term association between dairy consumption and risk of childhood obesity: a systematic review and meta-analysis of prospective cohort studies. *European Journal of Clinical Nutrition*, 70, 4, 414-423. https://doi.org/10.1038/ejcn.2015.226

Mangla, A., Dhamija, N., Gupta, U., Dhall, M. (2020). Anthropometric Markers as a Paradigm for Obesity Risk Assessment. *Journal of Biosciences and Medicines*., 8(2), 1-16. https://doi.org/10.4236/jbm.2020.82001

Matsuzawa, Y., Shimomura, I., Nakamura, T., Keno, Y., Kotani, K., Tokunaga, K. (1995). Pathophysiology and pathogenesis of visceral fat obesity. *Obes Res.* 1995, 3 Suppl 2, 187S-194S. https://doi.org/10.1002/j.1550-8528.1995.tb00462.x

Miyazaki, M., Noguchi, M., Takemasa, T. (2008). Intermittent reloading attenuates muscle atrophy through modulating Akt/mTOR pathway. *Med Sci Sports Exerc.*, 40(5), 848-855. https://doi.org/10.1249/MSS.0b013e318163275f

Müller, M.J., Braun, W., Enderle, J., Bosy-Westphal, A. (2016). Beyond BMI: Conceptual Issues Related to Overweight and Obese Patients. *Obes Facts.*, 9(3), 193-205. https://doi.org/10.1159/000445380

Piqueras, P., Ballester, A., Durá-Gil, J.V., Martinez-Hervas, S., Redón, J., Real, J.T. (2021). Anthropometric Indicators as a Tool for Diagnosis of Obesity and Other Health Risk Factors: A Literature Review. *Front Psychol.*, 12, 631179. https://doi.org/10.3389/fpsyg.2021.631179

Quann, E.E., Fulgoni, V.L., Auestad, N. (2015). Consuming the daily recommended amounts of dairy products would reduce the prevalence of inadequate micronutrient intakes in the United States: diet modeling study based on NHANES 2007-2010. *Nutr J.*, 14, 90. https://doi.org/10.1186/s12937-015-0057-5

Rautiainen, S. et al. (2016). Dairy consumption in association with weight change and risk of becoming overweight or obese in middle-aged and older women: a prospective cohort study. *The American Journal of Clinical Nutrition*, 103(4), 977-988. https://doi.org/10.3945/ajcn.115.118406

Raynal-Ljutovac, K., Lagriffoul, G., Paccard, P. et al. (2008). Composition of goat and sheep milk products: an update. *Small Ruminant Res*., 79, 57-72.

Recio, I., de la Fuente, A., Juárez, M. et al. (2009). Bioactive compounds in sheep milk. In *Park Y.W. 2009. Bioactive compounds in milk and dairy products*. Iowa: Wiley-Blackwell, 2009. s. 83-104.

Reeves, N.D., Narici, M.V., Maganaris, C.N. (2006). Myotendinous plasticity to ageing and resistance exercise in humans. *Exp Physiol*., 91(3), 483-498. https://doi.org/10.1113/expphysiol.2005.032896

Revilla, I., Escuredo, O., González-Martín, M.I. et al. (2017). Fatty acids and fat-soluble vitamins in ewe's milk predicted by near infrared reflectance spectroscopy. Determination of seasonality. *Food Chem*., 214, 468-477.

Rolland, Y., Czerwinski, S., Abellan Van Kan, G., Morley, J.E., Cesari, M., et al. (2008). Sarcopenia: its assessment, etiology, pathogenesis, consequences and future perspectives. *J Nutr Health Aging.*, 12(7), 433-450. https://doi.org/10.1007/BF02982704

Rolland, Y., Lauwers-Cances, V., Cristini, C., Abellan van Kan, G., Janssen, I., et al. (2009). Difficulties with physical function associated with obesity, sarcopenia, and sarcopenic-obesity in community-dwelling elderly women: the EPIDOS (EPIDemiologie de l'OSteoporose) Study. *Am J Clin Nutr*., 89(6), 1895-1900. https://doi.org/10.3945/ajcn.2008.26950

Romaguera, D. et al. (2011). Food composition of the diet in relation to changes in waist circumference adjusted for body mass index. *PloS one*, 6(8), 23384. https://doi.org/10.1371/journal.pone.0023384

Sakers, A., De Siqueira, M.K., Seale, P., Villanueva, C.J. (2022). Adipose-tissue plasticity in health and disease. *Cell.*, 185(3), 419-446. https://doi.org/10.1016/j.cell.2021.12.016

Sayón-Orea, C. et al. (2015). Association between yogurt consumption and the risk of metabolic syndrome over 6 years in the SUN study. *BMC Public Health*, 15, 170. https://doi.org/10.1186/s12889-015-1518-7

Shah, N.P. (2007). Functional cultures and health benefits. *Int. Dairy J.*, 17, 1262-1277.

Shakerian, M., Razavi, S.H., Ziai, S.A. et al. (2015). Proteolytic and ACE-inhibitory activities of probiotic yogurt containing non-viable bacteria as affected by different levels of fat, inulin and starter culture. *J. Food Sci. Technol*., 52, 2428-2433.

Sitárová, T. (2023). Food consumption in the SR in 2022. Bratislava: Ústredie ŠÚ SR, pp. 28. ISBN 978-80-8121-912-2.

Skrzypczak, M., Szwed, A., Pawlińska-Chmara, R. and Skrzypulec, V. (2007). Assessment of the BMI, WHR and W/Ht in pre- and post-menopausal women. *Anthropol. Rev.*, 70, 3-13.

Thorning, T.K., Bertram, H.C., Bonjour, J-P. et al. (2017). Whole dairy matrix or single nutrients in assessment of health effects: current evidence and knowledge gaps. *Am J Clin Nutr.*, 105, 1033-1045. https://doi.org/10.3945/ajcn.116.151548

Tunick, M.H., Van Hekken, D.L. (2015). Dairy Products and Health: Recent Insights. *J Agric Food Chem.*, 63(43), 9381-9388. https://doi.org/10.1021/jf5042454

Unger, R.H., Scherer, P.E. (2010). Gluttony, sloth and the metabolic syndrome: a roadmap to lipotoxicity. *Trends Endocrinol Metab*., 21(6), 345-352. https://doi.org/10.1016/j.tem.2010.01.009

Vagenas, G., Roussis, I.G. (2012). Fat-derived volatiles of various products of cows', Ewes', and Goats' milk. *Int Journal Food Prop.,*15, 665-682.

Van Gaal, L.F., Mertens, I.L., De Block, C.E. (2006). Mechanisms linking obesity with cardiovascular disease. *Nature*,444(7121), 875-880. https://doi.org/10.1038/nature05487

Vargas-Bello-Pérez, E., Tajonar, K., Foggi, G., Mele, M. (2022). Consumer attitudes toward dairy products from sheep and goats: A cross-continental perspective. *J Dairy Sci.,* 105, 11, 8718-8733. https://doi.org/10.3168/jds.2022-21894

Vaskonen, T. (2003). Dietary minerals and modification of cardiovascular risk factors. *The Journal of nutritional biochemistry*, 14(9), 492-506.

Veldhorst, M., Smeets, A., Soenen, S., Hochstenbach-Waelen, A., Hursel, R., Diepvens, K. et al. (2008). Protein induced satiety: effects and mechanisms of different proteins. *Physiology & behavior*, 94(2), 300-307.

Visioli, F., Strata, A. (2014). Milk, dairy products, and their functional effects in humans: a narrative review of recent evidence. *Adv Nutr*., 5, 131-143.

Wang, W., Wu, Y., Zhang, D. (2016). Association of dairy products consumption with risk of obesity in children and adults: a meta-analysis of mainly cross-sectional studies. *Annals of Epidemiology*, 26, 12, 870-882. https://doi.org/10.1016/j.annepidem.2016.09.005

World Health Organization. (2008). Waist Circumference and Waist-Hip Ratio: *Report of a WHO Expert Consultation*, World Health Organization: Geneva, Switzerland, 2008.

World Health Organization. (2020). Obesity and Overweight. Available online: https://www.who.int/en/news-room/fact-sheets/detail/obesity-and-overweight (accessed on 27 May 2024).

Yu, J.Y., Choi, W.J., Lee, H.S., Lee, J.W. (2019). Relationship between inflammatory markers and visceral obesity in obese and overweight Korean adults: An observational study. *Medicine (Baltimore)*., 98(9), e14740. https://doi.org/10.1097/MD.0000000000014740

Zemel, M.B. (2005). The role of dairy foods in weight management. *Journal of the American College of Nutrition*, 24(6 Suppl), 537S-46S.