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ORIGINAL PAPER

Price calculation of wooden bariatric beds

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Abstract
In the field of interior and furniture, the pursuit of comfort has always been based on the anthropometric dimensions of the user. When optimizing the dimensions of the bed for the needs of today's population, we start from the forecasted values of the relevant body dimensions, i.e. height and weight. Based on previous research, we can conclude that the anthropometric dimensions of the adult Slovak population after reaching the age of adulthood have increased statistically significantly by approx. 4.5–5% since the last measurements in 1987, from the point of view of the body growth process. In connection with the aforementioned findings, it is necessary for furniture companies producing bed furniture to adjust their calculation procedures for price formation depending on the needs of users, in order to forecast their financial situation. The goal of the work is to determine the cost increase for bariatric respondents, based on the determined dimensions of the wooden bed compared to a standard manufactured bed, and to determine the calculation formula for single-piece production. The results show that increasing the dimensions of the bed will increase the total costs by approximately 70%.

Key words: bed furniture dimensions; dimensions of bariatric bed; calculation; costing; contribution margin

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1. Introduction

Globalization of the market causes economic growth and increases the overall standard of living (Grofcikova 2016; Cogoljevic et al. 2022). Better availability of food, and sedentary work significantly affect people's diet and overall lifestyle, which causes a significant increase in the body weight of the population worldwide (Freedman & Ogden 2010; Finucane et al. 2011; Gomula et al. 2015). Especially among young adults, there is a very rapid increase in body weight (Thompson 2008). Growth and weight changes in the population also occur over time. Secular trends have been documented in many countries of the world since the 19th century (Komlos & Lauderdale 2007; Leitao et al. 2013; Fudvoye & Parent 2017). In this context, research by Herron (2004) points to the fact that healthcare costs are 44% higher among severely obese patients, which of represents a public health problem in developed and developing countries.

The term bariatric was coined around 1965 (Hedley 2004) from the Greek ground *bar–*, the suffix *–iatr*, and the suffix *–ic* ("relating to"). This field includes diet, exercise, and behavioral therapy for weight loss, as well as drug therapy and surgery. The mentioned term is also used in the medical field as a designation of people of larger dimensions.

Being overweight and obese are growing health problems in contemporary society (Bray 2004). Obesity is defined as a body mass index (BMI) of 30 or more. There are many harmful health effects of obesity (Flegal et al. 2005; Gregg et al. 2005). Individuals with a Body Mass Index (BMI) above 30 have a much higher risk of health problems (Ikeda et al. 1999; Bagozzi et al. 2004). Despite everything, the number of bariatric respondents in the population is growing. As part of bariatric care, it is also necessary to consider the appropriate selection of furniture not only in the hospital but also in the home (Cooper 1995; Rush 2005). If these patients have suitable chairs, armchairs, and beds, it will be easier to transfer them to a standing or moving aid (Bakewell 2013; Dockrell & Hurley 2021). According to NCD-RisC (2016), if such trends continue, the prevalence of obesity worldwide will be 18% for men and more than 21% for women by 2025.

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Obesity as an increasing global epidemic is defined by the World Health Organization (WHO) as a disease that affects virtually all socioeconomic status in all developed and developing countries, including all age groups, and represents an alarming problem (Kosti & Pnagiotakos Demosthenes 2006; WHO 2022). Dee et al. (2014) concluded that there is a gradient between increasing BMI and direct health care costs as well as indirect costs due to reduced productivity and early premature mortality. These changes must be taken into account when dimensioning a wide variety of daily consumption products (furniture, clothing, footwear, etc.). The manufacturer's efforts to optimize and rationally standardize products must be based on knowledge of the current statistical properties of users' body dimensions. Since there are currently standardized dimensions of bed furniture (most often 200 cm × 90 cm), many users with excessive height or weight cannot use such beds for perfect relaxation. Although some manufacturers try to accommodate individual clients, standard dimensions suitable for most bariatric respondents are not specified. Bed dimensions were calculated based on research by Hitka et al. (2022a), where a bed length of 230 cm is required for the respondent to sleep comfortably. The width of 141 cm was intended for the comfortable sleeping of the bariatric respondent due to its rotation in both directions without lateral reposition. The aim of the work is to determine the cost increase for bariatric respondents based on the determined dimensions of the bed compared to a standard manufactured bed and to determine the calculation formula for single-piece production.

2. Material and methods

In previous research (Kelly Kroemer 1990; Navrátil & Klein 1994; Grbac et al. 1998; Barli et al. 2006; Oliveira et al. 2012), it is possible to meet several approaches and opinions to determine the basic parameters of wooden bed furniture, i. e. to determine the optimal length, width and height of the bed surface from an anthropometric and ergonomic point of view. When defining the length of the bed for bariatric respondents, we base it on the secular trend of the current population of men aged 1–25. Empirical measurements of the stature height values of the current male population were carried out from 2001 to 2022 on a sample consisting of 1,678 men aged 18–25 coming from the entire territory of Slovakia. When defining the width of the bed, we base it on the values of the relevant body dimensions of the bariatric respondents. Due to the fact that bariatric respondents show wider hips than shoulders within their figure, the maximum width of the body is replaced by the hip width in our case. An experimental sample of bariatric respondents was analyzed without gender differences. The data were collected between 2020 and 2022 in Slovak healthcare facilities.

The production of wooden beds for bariatric respondents will be based on single-piece production. For this reason, it is necessary to calculate the price separately. The calculations are based on the calculation formula, which represents a list of individual types of costs, which should be supplemented with the method of quantifying these items concerning the calculated performance (Table 1).

Table 1. Typical calculation formula.

A	Direct material
B	Direct wages
C	Other direct costs
DC = A + B + C	DIRECT COSTS
E	Acquisition overhead expenses
F	Overhead (technological) expenses
G	Overhead (non-technological) expenses
H	PRODUCTION COSTS (PC_1)
I	Administrative overhead expenses (80% PC_1)
PC_2 = D + E + F + G + H + I	PRODUCT COSTS (PC_2)
J	Distribution expenses (30% PC_1)
TC = PC_2 + J	TOTAL COSTS
P	Profit (20%)
P_3 = TC + P	PRICE WITHOUT VAT (PC_3)

In further calculations, the costing overhead method was used, which is considered to be the most frequently used method, because, for most companies, their output is at least two products, the costs and character of which differ from each other (Myskova & Hajek 2016). It has a simple form and uses division into direct and indirect costs. This type of calculation uses cost allocation bases, which can be expressed in natural or value quantities, to assign indirect costs to performance. In general, the cost allocation basis is understood as the quantity by which indirect costs are assigned to a unit of output. Cost allocation basis can be distinguished into monetary and natural, depending on the form in which the base is expressed. On a monetary cost allocation basis, an overhead charge is calculated, and an overhead rate is calculated on a natural basis. In both cases, this is the share of overhead costs to the cost allocation base. In practice, it is considered a universal procedure for scheduling the costs of several types of products. Direct wages and direct materials are included in direct costs, and the remaining part of direct costs is included in overhead costs. The job-order method is mainly used in single-pieces production and in small series, which correspond to the beds for the needs of bariatric respondents. It is mostly about the production of several products but with a low degree of repetition. The main idea is to find out the costs of orders separately, on the so-called order form, in which both direct costs and overhead costs for production are recorded. They are scheduled for the given orders according to a suitable schedule base. The job-order method is clear and simple, which many companies consider an advantage.

3. Results

Empirical measurements of the stature height values of the current male population were carried out from 2001 to 2022 on a sample consisting of n = 1,678 men aged 18–25 coming from the entire territory of Slovakia (Hitka et al. 2022a).

A direct survey technique was used to obtain data on bariatric respondents. The data were obtained by measuring selected anthropometric characteristics body weight, stature height, waist circumference, and hip circumference. BMI was then calculated. The results are presented in Table 2.

Table 2. Descriptive statistics of bariatric respondents.

Indicator	n	Arithmetic mean	Median	Minimum	Maximum	Quantiles					St. deviation
						1%	5%	50%	95%	99%	
Body weight [kg]	225	143.48	139.0	93.0	242.0	97.00	105.00	139.00	191.00	233.00	27.36
Stature height [cm]	225	171.12	170.0	150.0	199.0	150.00	156.00	170.00	187.00	196.00	9.02
Waist circumference [cm]	225	137.14	136.0	100.0	188.0	106.00	113.00	136.00	169.00	184.00	16.81
Hip circumference [cm]	225	146.76	145.0	108.0	192.0	110.00	121.00	145.00	173.00	191.00	15.71
Sitting width according to waist [cm]	225	43.69	43.31	31.85	59.87	33.76	35.99	43.31	53.82	58.60	5.36
Sitting width according to wais hip [cm]	225	46.74	46.18	34.39	61.15	35.03	38.54	46.18	55.10	60.83	5.00
BMI	225	48.99	47.96	35.49	89.75	36.36	39.04	47.96	60.94	76.38	7.89

The dimensions of a single bed corresponding to secular trends in the area of stature height and body weight of bariatric respondents are based on research by Hitka et al. (2022a). The length of the bed is based on the 95th quantile of men's standing height. The width of the bed is based on the sitting width of the bariatric respondent's seat (Table 3). The stated dimensions will provide the bariatric respondent with sleep with the possibility of turning in both directions without lateral repositioning. The obtained values were rounded up to whole numbers.

Table 3. Recommended length dimensions of the bed.

	Used value 95% quantile of stature height	Dimensions of bariatric beds
Length (L)	Smaller space	220 cm
	Middle space	230 cm
	Large space	240 cm
Width (b_1)	For all lengths	141 cm
Height (hp_1)	For all lengths	66 cm

The price of bed furniture is closely related to the renewability of the material from which the furniture is made and the energy demand of its processing. Wood best suits the material conditions affecting the price because it is a completely renewable raw material with low energy requirements during processing and with easily processed waste (Vilkovska et al. 2018). When producing beds in the case of bariatric respondents in the form of a single-piece order, it will be necessary for companies producing bed furniture to adjust their calculation procedures for price formation in those areas where the causal relationship between the costs incurred and the relevant performance is expressed (Barroso et al. 2005).

To calculate the price of bariatric beds of various size modifications (220 × 141 cm; 230 × 141 cm; 240 × 141 cm) a typical calculation formula was used, which is the most common tool for determining unit costs in manufacturing companies. It is a relatively flexible method when changing some parameters. Direct costs took into account consumption standards and time standards. The standard of direct material consumption was based on the technical documentation. Calculations of the price of bariatric beds were compared with the standardized dimensions of bed furniture (most often 200 cm × 90 cm), in which the direct material consumption is 4.39 m^2. Considering the recommended length dimensions of the bed (Table 3), the material consumption standards for individual bed sizes (Table 4) were calculated, which represent the value expression of the material consumption standard, while the data were tied to the assumed purchase price of the material (€3.69/m^2).

From the results presented in Table 4, it follows that as a result of increasing the dimensions of the bed, there will be a real increase in the consumption of direct material.

Table 4. Material standard.

Bed dimension [cm]	200 × 90	220 × 141	230 × 141	240 × 141
Material standard [m^2]	4.39	7.57	7.91	8.25
Material standard [€]	16.20	27.93	29.19	30.44

The share of direct wages in total costs is based on time standards. The standard of time consumption for the basic type of bed was set by the manufacturer at €3.20. The number of standard hours per product was set by the manufacturer at a value of 0.661 Nh/piece (Nh – Normative hour) for the standard product. Due to the work with larger pieces of material, more complex handling and moving of materials and parts of unfinished production, there was a change in time standards. For individual modifications of dimensions, the time consumption standard was set by the manufacturer at a value of 0.85 Nh/piece. Table 5 presents the consumption time standards taking into account labor with larger pieces of material, both in natural and in monetary terms.

Table 5. Time consumption standard.

Bed dimension [cm]	200 × 90	220 × 141	230 × 141	240 × 141
Time standard [Nh]	0.661	0.85	0.85	0.85
Time standard [€]	3.20	4.11	4.11	4.11

The last item included in direct costs was other direct costs. It was mainly about connecting materials, con-

necting pins, and other auxiliary materials. Due to their nature and almost identical use as for the standard product, their amount remained at the same value, namely €0.96/pc.

A differentiated surcharge calculation was used to determine overhead charges for individual overheads (production, supply, administrative, and sales). As we are currently in a period of increasing inflation, we consider it more correct and advantageous to use natural cost allocation bases, as they are currently more stable than the monetary cost allocation bases classically used in many types of research. This approach applies in the case of simultaneous production of several modifications.

The cost allocation basis for determining the supply overhead was direct costs (in the amount of 100%). Production overhead was divided into technological and non-technological. For technological production overhead, an overhead rate of €3.50/Nh was set for the original product. Due to the current increase in energy prices, the overhead rate for technological production overhead was increased by 35%, which represents a value of €4.73/Nh. For other overhead items, charges were determined using the selected schedule bases:

(i) (non-technological production overhead (schedule base: direct material – 10%),
(ii) supply overhead expenses (schedule base: direct material + direct wages),
(iii) the share of administrative overheads and distribution costs is based on the expert opinions of the financial managers of the production companies addressed, the administrative overhead expenses was determined as 80% of production costs, taking into account the expected increase in wages as a result of increasing inflation,
(iiii) sales overhead expenses was determined as 30% of production costs.

Table 6 presents the calculation for the original type of bed and its modifications, assuming a 20% profit from the full own costs.

Based on the achieved results (Table 6), we can conclude that when the bed dimensions are increased to 220 × 141 cm, the total costs will increase by 64.46% (compared to the standardized bed dimensions of 200 × 90 cm). If the dimensions are increased to 230 × 141 cm, the total costs will increase by 70.52%, and if the dimensions are increased to 240 × 141 cm, the total costs will increase by 76.52%. At a profit level of 20%, it can be further expected that in terms of value, the selling price will increase by 70.97 €/piece (220 × 141 cm), or to 77.64 €/piece (230 × 141 cm) or up to 84.25 €/piece for bed dimensions 240 × 141 cm.

4. Discussion

In the history of man's development, his body dimensions have always been and still are a determining criterion for the creation of the objects he used. Previous measurements and research (Kalka et al. 2019; Scott et al. 2020; Moelyo et al. 2022) showed that the height and body weight of women and men changed significantly over time. At the same time, the number of obese people is growing rapidly, and obesity is becoming a "modern epidemic" (Aruna et al. 2015; Eibl & Rozengurt 2021). Changes associated with rising living standards, better availability of food, and changes in people's lifestyles have a significant impact on the determination of items of daily use. The response to these changes is visible above all in industries where consumption as the main economic factor has a decisive influence. These are the areas of the automotive, aviation, furniture, clothing industry, and others (Baroutaji et al. 2019; Nedeliakova et al. 2020; Musova et al. 2021; Sala et al. 2021; Dudziak et al. 2022). Since special wooden beds for bariatric respondents are not currently produced, problems with the higher weight of users must also be taken into account when dimensioning bed furniture.

A wooden bed as a basic item of furniture is most often made of beech (*Fagus sylvatica* L.) and at the same time, it is subjected to high demands (Cameron 2002; Klement et al. 2019; Atanasov 2021). The size and rigidity of the bed must correspond to the human body and changes in position during sleep. From an anthropometric point of view, the length, width, and height of the bed surface are important. Length and width have an effect on the size of the bed surface, while height is of great importance for comfortable standing and possibly sitting (Jelačić 2002). Since in recent years the number of people with severe

Table 6. Calculation for individual types of products in €.

Indicator	Original beds dimensions	Bariatric beds dimensions		
	200 × 90 cm	220 × 141 cm	230 × 141 cm	240 × 141 cm
Direct material	16.20	27.93	29.19	30.44
Direct labour	3.20	4.11	4.11	4.11
Other direct costs	0.96	0.96	0.96	0.96
DIRECT COSTS	20.36	33.00	34.26	35.51
Acquisition overhead expenses	19.40	32.04	33.30	34.55
Technological production overhead	2.31	4.02	4.02	4.02
Non-technological production overhead	1.62	2.79	2.92	3.04
PRODUCTION COSTS (PC_1)	43.69	71.85	74.50	77.12
Administrative overhead expenses (80% PC_1)	34.95	57.48	59.60	61.70
PRODUCT COSTS	78.64	129.33	134.10	138.82
Distribution expenses (30% PC_1)	13.11	21.56	22.35	23.14
TOTAL COSTS	91.75	150.89	156.45	161.96
Profit (20%)	18.35	30.18	31.29	32.39
PRICE WITHOUT VAT	110.10	181.07	187.74	194.35

obesity (BMI > 40 kg/m^2) is increasing rapidly (Ben Tahar et al. 2022; Williamson et al. 2022), it is necessary to design beds with a perspective for people with a high BMI.

Previous research deals with the dimensions of beds and bed components for body heavier users (Dvouletá & Káňová 2014). Research by Muir and Archer-Hees (2009) focused on the use of wider beds for patients weighing more than 159 kg. Gourash et al. (2007) recommend the use of special beds for users weighing more than 147 kg or with a BMI greater than 55 kg/m^2, but it is not clear how they worked out at these values. Kramer-Jackman and Kramer (2010) deal mainly with bariatric hospital bed safety. Magazine et al. (2021) dealt with forecast demand for specialized bariatric beds. Other research deals with the issue of bariatric management mainly from a medical point of view (Turner & Santosa 2021; Alexis et al. 2022). In addition to dimensions (Hitka et al. 2018) and structural load (Réh et al. 2019; Hitka et al. 2022b), it is also necessary to address economic aspects, which we deal with in our research. The research aimed to determine the increase in the cost of manufacturing beds for bariatric respondents compared to a standard manufactured bed and to establish a calculation formula for single-piece production. The costs affect the pricing (Durisova et al. 2019). Due to the production of oversized products has its specifics the pricing used must take into account several factors that differentiate the products from standard sizes. Pricing must cover all company costs, including unexpected ones (Myskova & Hajek 2020). Cost-based pricing is advantageous because of its simplicity for business practise and the availability of documentation from cost accounting (Myskova 2009). For this reason, it is the most widely used method compared to others.

Demand-oriented pricing can also be considered because of its ability to regulate market demand, but its application is problematic in smaller companies which are the subject of the study. Instead, market surveys can be used to determine whether, for example, bariatric patients can financially afford to get a bed with a lower cost (see, e.g., a survey conducted in December 2022 on a sample of over 1,000 respondents). Competitive pricing was not taken into account due to the specificity of production (the market is small, and consequently, so is competition). Customer- and profit-oriented pricing can be considered, but after taking into account the characteristics of typical customers and their financial resources, the possibility of handling a surcharge for differences in the price of beds by a health insurance company would also have to be considered, which would have to be the subject of further research, including surveying the possibilities and interest of health insurance companies.

The price of wood as an input material, which has increased sharply in the last period also due to the energy crisis, can significantly affect the calculation formula and the obtained results. Therefore, it will be necessary to monitor and predict the development of the wood market in the future (Suchomel & Gejdoš 2007; Gejdoš & Potkány 2017). It will also be important to continuously improve the quality assessment of the raw material through digitization and automation procedures (Gergeľ et al. 2019). When using classic overhead calculation, it is possible to refine its calculation by using different cost allocation bases. Considering this, we recommend the use of natural bases. Another way to refine the calculation is a more detailed analysis of overhead items and moving part of it to direct costs. In the case of custom production, single-piece production, or however, with small series, the redistribution of individual overhead items is complicated. It significantly depends on the structure of the production program and the planned volume of production.

The trend of designing custom-made ergonomic furniture is related to adaptation and increasing demand for wood products. It provides consumers with more product choices. It is related to customization and has increased in the wood products industry and gives consumers more product choices (including material use) like tables, doors, closets, timber windows, etc. (Kwidziński et al. 2021). An example could be a product where consumers can choose the wood species, finish, and hardwood that will be applied to a given design.

5. Conclusion

Customers are becoming more and more demanding. They increase the demands not only for companies to introduce innovations in their activities, but also the diversity and specificity of products. At the same time, they also create pressure on the social responsibility of companies. When deciding to buy a product, the customer no longer only looks at criteria such as price, performance, or design, but product safety and the impact on the environment are also becoming important criteria.

A system for the design of customized ergonomic furniture (chairs, beds, kitchen interiors, etc.) using anthropometric dimensions or other specific needs influenced by increasing demand from customers to manufacturers (Gejdoš et al. 2018). The individualization of production is demanding for the company in terms of materials, production, technology, and logistics. Customers especially those with larger dimensions (weight, height) need the mentioned individualization. It is essential for them. Adapting the production process to specific requirements is also challenging from a financial point of view, which is reflected in the final price of the product. However, the final effect in the case of satisfaction with the request is significant for the customer.

Although we focused on the bariatric group of the population in the research, it is necessary to realize that the population, in general, is growing and the current dimensions of the bed, especially the length, are unsatisfactory for a larger part of the population. Manufacturers should therefore consider the idea of changing the

dimensions of the offered products, not only beds but also chairs, tables, and other types of furniture, which will ensure greater comfort and well-being for users.

Due to the secular trend in the anthropometric dimensions of the adult population of Slovakia and the increase in the weight of the population, there was a need to consider changes in the dimensions of bed furniture. The rate of increase in population weight is closely related to growth in consumption and welfare and is very difficult to estimate. For this reason, it is necessary to continue to monitor the dimensions of the population and then incorporate them into the dimensions of objects of daily consumption. If the business activity is to be successful in the long term, it must be systematic, managed, and, above all, based on purposeful innovations.

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