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What makes order picking so physically demanding? – Ergonomic evidence from a large-scale lab experiment using subjective metrics

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Abstract: Order picking is a critical and resource-intensive process within warehouse operations. Many warehouses still heavily rely on human operators for picking orders. However, human order pickers have become a scarce resource, partly due to the physically demanding nature of the order picking process. If warehouses want to remain competitive, they should properly account for physical worker well-being. Unlike earlier research which mainly focused on objective metrics, this paper investigates the factors that contribute to subjective physical exertion. Specifically, we conduct a large-scale lab experiment (N=164) and derive the perceived ergonomic exertion with the Borg CR-10 scale. Results show the significance of shelf height, product weight, and product quantity on ergonomics. On the other hand, elements such as picker sociodemographics, the prevailing incentive system, or the degree of autonomy are less suitable to predict perceived physical exertion; they might be more relevant to influence psychosocial well-being though. Our study shows thus that physical worker well-being is primarily determined by the attributes of the order to be picked. Based on our results we propose several suggestions for future research and ergonomic OP system design.

Keywords: Warehousing, Order picking, Human factors, Ergonomics, Subjective well-being, Experiment.

1. INTRODUCTION

Warehouses play an important role in the success or failure of a company's supply chain. One of the costliest activities within a warehouse is order picking (OP), the process of retrieving products from their storage locations to prepare them for shipping (De Koster et al., 2007). Although Industry 4.0 has introduced several technological advancements to warehouses, many of them still heavily rely on human operators for the picking process (De Lombaert et al., 2023). Ironically, those people have become a scarce resource to the flourishing warehousing sector (Min, 2007), mainly due to the physically demanding nature of OP. Properly accounting for worker well-being is therefore a precondition for sustainable growth.

Industry 5.0 responds to those concerns by simultaneously considering human well-being and automation-driven productivity gains. However, despite the increased conscientiousness regarding the importance of human well-being, OP is inherently repetitive and physically demanding. This is characterised by the high prevalence of musculoskeletal disorders among warehouse workers and its detrimental impact on organisational performance. Fortunately, the Human Factors or Ergonomics (HF/E) discipline has recently been introduced to warehouse research and aims at mitigating the negative externalities of picking orders (Grosse et al., 2015). Many HF-integration opportunities, however, remain untapped or underexplored in the current warehousing literature (Grosse et al. 2017).

The HF category which has received the most attention in warehouse literature is the physical one (Sgarbossa et al., 2020). However, unlike objective physical indicators (e.g. heart rate), subjective metrics to assess physical exertion (e.g. perceived discomfort) remain understudied, although earlier research has shown that long-term musculoskeletal pain strongly relates to the discomfort felt by workers (Hamberg-van Reenen et al., 2008). Against that backdrop, De Lombaert et al. (2023) advocate the importance of including subjective metrics to devise human-centric OP systems. In the case of physical well-being, this translates to accounting for the underlying factors that make an order physically demanding to pick in a subjective sense. The quantification and policy implications of the subjective physical exertion induced by picking orders are this paper's main focus.

In this paper, we address the following research question: What factors drive the subjective perception of an order being physically demanding? The contributions of this paper are twofold. First, we holistically consider order-, context-, and picker factors to evaluate an order's physical exertion. Thereby, we deepen the understanding of salient features for effective industrial ergonomics. Second, we fill the gap in subjective order/task assessment in OP with an extensive lab experiment involving a large number of highly relevant participants. The remainder of this paper is structured as follows. Section 2 presents relevant literature, whereas Section 3 discusses our methodology. Section 4 focuses on the results, which are further discussed and synthesised in Section 5.

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2. LITERATURE REVIEW

Earlier research highlights the importance of considering physiological metrics in decision models (Battini et al., 2016). The study of Diefenbach et al. (2024) is a fine example of the joint optimisation of ergonomics and performance, using empirical data. When examining ergonomics in warehouses, researchers can resort to two distinct types of metrics: objective and subjective ones. The remaining part of this section elaborates on how these are being used in studies that examine the physical well-being of order pickers.

2.1 Objective physical well-being

The vast majority of studies that examine physical well-being employ objective metrics. These involve objectively measurable data obtained via sensors or other technological devices. The aim is to have a consistent metric which is impartially constructed. There is a myriad of possible metrics that can be adopted, such as heart rate, muscle activity, or postural metrics.

In their study, Battini et al. (2016) make use of the energy expenditure concept to account for worker ergonomics when evaluating storage assignment policies. Energy expenditure, referring to the amount of energy a person requires to complete a certain task, is derived from standardised formulations. The authors exemplify that picking from the lowest levels requires more energy than picking from the highest levels, which makes bottom-shelf picks ergonomically more demanding than top-shelf picks in their study. The study of Finco et al. (2023) also looks at ergonomics, albeit in workstation configuration. Making use of a motion capture system that monitors joint angles, unbiased postural metrics are calculated, such as REBA, RULA, and OWAS. The results of their experiment show that worker postures benefit from inclined bins that are placed above the order bin and in front of the order picker. Moreover, those configurations are also found to be beneficial for worker productivity. Like the previous study, Wakula et al. (2021) also investigate workstation configurations and find that product weight and picking frequency are detrimental for long-term ergonomically viable work. In addition, the authors raise the point that alternating between standing and walking is favourable for physical well-being. These findings are derived from an analysis involving motion-captured data that were converted into EAWS points. Last, Lavender et al. (2021) explore the preconditions of an ergonomic slotting strategy with two experiments. Using both kinematic metrics and electromyographic responses, the first experiment shows the significance of shelf height on ergonomics. Item weight, on the other hand, is not significant, although this may be due to the overly narrow set of item weights, the authors claim. In fact, their presumption is affirmed in the second experiment, albeit tailored to replenishment operations, where both shelf height and item weight significantly impact physical worker well-being.

Although focusing on different OP system design aspects, the above studies agree on the importance of shelf height/layout and product weight on ergonomics. However, Finco et al. (2023) raise the interesting point that a holistic analysis, where also environmental factors –and by extension picker factors– are considered, would be utterly valuable for an ergonomic OP system design.

2.2 Subjective physical well-being

Unlike objective metrics, subjective physical well-being metrics are considerably less used in OP literature, despite being a good predictor for future musculoskeletal pain (Hamberg-van Reenen et al., 2008). Subjective metrics pertain to one's perceptions and psychological state in relation to the work environment. They are often obtained through self-reported data, such as questionnaires or direct feedback. The main idea is to have an idiosyncratic view of how a particular worker feels in the workplace.

The few studies in OP that employ subjective physical well-being metrics rely on the Borg scale. This is a tool to assess the perceived physical exertion or discomfort for a given task (Borg, 1990). Individuals rate their perceived task intensity, regardless of the actual objective physical effort such as heart rate. Depending on the Borg scale type, those ratings vary between 6 and 20 or between 0 and 10. For example, Steinebach et al. (2021) use the former type when assessing ergonomic storage location assignments. Participants rate their perceived exertion at the beginning, halfway through, and at the end of an OP experiment, ranging between 6 (light exertion) and 20 (maximal exertion). This study demonstrates that purely distance-minimising storage location assignment policies fall short of ergonomic optimality. Larco et al. (2017) also consider storage assignment decisions, albeit with the Borg CR-10 scale. Study subjects were instructed to directly rate the perceived discomfort after every product pick on a scale from 0 (no discomfort at all) to 10 (maximum discomfort). Those ratings are used as input for an OLS regression to predict the discomfort for a given product at a given location. Data collection involved 5 and 7 employees from two different companies, totalling 235 and 749 observations respectively. Results show that picking height, number of products, and product weight consistently contribute to perceived worker discomfort.

In sum, the few studies that employ subjective physical well-being metrics are consistent with those using objective metrics, i.e. shelf height and product weight have a strong impact on worker ergonomics. However, product quantity also seems an important determinant of subjective well-being. This substantiates the need to consider a wide set of underlying factors when assessing physical workload (Finco et al., 2023; Larco et al., 2017). Despite its proven relevance, Borg scale ratings have rarely been invoked in comprehensive warehouse experiments. Our study uses a Borg scale to examine the factors that induce physical exertion from a subjective perspective, conceptualising workers' perceptions in relation to the work environment.

3. METHODOLOGY

Motivated by the need to holistically evaluate the factors that make an order physically demanding to pick, we conducted a lab experiment in which participants performed a series of OP tasks. We then evaluate their subjective physical well-being to formulate preconditions for ergonomic OP. Compared to a field experiment, a lab environment facilitates the control and/or manipulation of several factors, adding to the holistic evaluation approach our study takes; participants' attitudes are gauged with a minimum of interference from extraneous variables.

3.1 Warehouse layout and participants

To boost the validity of our study, this study is conducted in a Dutch lab that was specially erected to accommodate empirical studies related to OP. The warehouse layout is depicted in Figure 1. In total, 113 unique SKUs are stored within the 288 available storage locations. The latter is calculated by: #aisles (4) * #racks per aisle (18) * #levels per rack (4). Rack levels were located at 0.20, 1.08, 1.60, and 2.00 meters above ground level. Storage location assignments were random, apart from high-weight products (≥5kg), which were not stored at the top level for safety reasons. The depot was located on the front side of the warehouse floor and was used as administration and staging area. Interestingly, this research lab is integrated into a school building which hosts vocational education in logistics. Hence, the participants of our experiment all have a highly relevant background. In total, 164 vocational Dutch students took part in our study, of which ±10% is female. The average participant was 17.37 years old (*SD*=1.67; median=17; range=15-24). Students voluntarily participated in the experiment which took approximately 1.5 hours and the data collection phase lasted for 12 weeks.

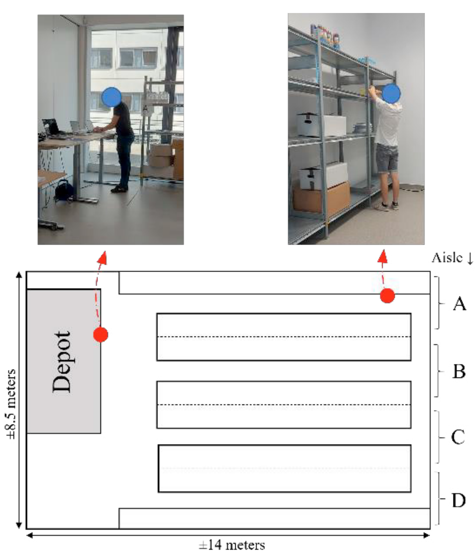

Figure 1. Warehouse layout and picking procedure.

3.2 Experimental design

In line with recommendations from prior research, we consider multiple sources of physical discomfort, in particular order-, context-, and picker factors. *Order factors* refer to the characteristics of the order that need to be picked, for example unit weight, horizontal travel distance to its location, picking height, and unit quantity. In our experiment, an order consists of a single SKU, although multiple units of that SKU could be picked (range=1-56). The lab warehouse accommodates a wide variety of SKUs with very diverse characteristics, e.g. unitary weight (mean=0.67kg; *SD*=2.06kg; range=0.3gr-15.15kg) or required walking distance (mean=7.97m; *SD*=3.29m; range=2.4m-16.65m). *Context factors*, on the other hand, pertain to the work design characteristics and (temporal) conditions in the warehouse. In the experiment conducted, subjects either worked under a group performance-based incentive system, or under an incentive system based on individual merits. In addition, half of the time, subjects worked in a system where they could choose their next order among a set of two possible orders, i.e. participatory order assignments (De Lombaert et al., 2024). In the other half, subjects were deprived of this autonomy. Apart from these two work design characteristics, it is reasonable to also consider the number of preceding picks at picker level to control for temporal conditions (Larco et al., 2017). We consider the above (control) variables to simulate a wide variety of possible OP contexts. Last, *picker factors* relate to the distinct characteristics of individual pickers, such as their age, length, gender, and educational level. Including the above factors allows to holistically evaluate and quantify the factors that impact subjective physical well-being (Finco et al., 2023).

3.3 Experimental procedure and measures

To simulate a real work environment, participants simultaneously worked in groups of three individuals. Only one group had two members since the third person had to leave early. At the beginning of the experiment, the participants filled in a sociodemographic questionnaire. Subsequently, they familiarised themselves with the picking process and were given instructions on how to proceed in the experiment. In particular, at the depot, an order is assigned to the picker, either by choice or the first one in the queue of outstanding orders. After having picked the product(s), the picker returns to the depot and enters the check digits in a dedicated computer (See Figure 1). This is to check if the correct product (and quantity) was picked. Finally, the picker also enters a Borg score. Given the adolescent profile of our sample (see Section 3.1), we opted for the Borg CR-10 scale to assess subjective physical well-being, since a 0-10 scale is more intuitive than a 6-20 scale. Once these administrative tasks were completed, the picked order was placed in the staging area and a new order could be assigned. Products were replenished by the researcher during the picking process. Orders were picked for 20 minutes after which the participants had a brief rest and the last products were replenished. Finally, the same procedure was repeated, albeit with the other order assignment mechanism. The order assignment mechanism sequence to which the participants were exposed was carefully balanced among groups. Students were incentivised by means of a lottery, to which their name was added every time they correctly picked an order. After the data collection phase, 18 winners were contacted (9 for the individual performance-based incentive system, and 3*3 for the group-based system). This procedure generated a database of Borg scores associated with specific order-, context-, and picker factors, which were rigorously analysed.

4. EMPIRICAL ANALYSIS & RESULTS

The total number of Borg observations amounts to 6643. However, 588 of those are excluded due to various reasons, including picking errors or invalid data entries. The remaining 6055 observations were used as input in linear OLS regression models with Borg score as dependent variable.

As depicted in Figure 2, the model was gradually developed to scrutinise the incremental impact of each factor. Models 1 to 3 are basic linear OLS regressions to get a first intuitive grasp of each factor's significance, whereas model 4 is a more advanced and definitive linear mixed-effects model. Table 1 shows the corresponding independent variables of each order-, context-, and picker factor.

$$\boxed{\boxed{\boxed{\boxed{Y = \beta_0 + \varepsilon + \sum_{i \in (\text{order factors})} \beta_i X_i}_{\text{Model 1}} + \sum_{j \in (\text{context factors})} \beta_j X_j}_{\text{Model 2}} + \sum_{k \in (\text{picker factors})} \beta_k X_k}_{\text{Model 3}} + \begin{pmatrix} \text{individual} \\ \text{group} \end{pmatrix} \text{Random effects}}_{\text{Model 4}}$$

Figure 2. Schematic overview of the modular analysis approach.

Table 1. Overview of the independent variables.

Factor category	Factor (see Section 3.2)	Independent variable in regression model [unit]
Order	Total weight	Quantity [number of units in the order] * Unit_weight [kg per unit]
	Horizontal travel distance from depot to location	Distance [meter]
	Picking level	L_0 = 1 if the SKU is located at the lowest level, 0 otherwise L_1 = 1 if the SKU is located at the second highest level, 0 otherwise L_2 = 1 if the SKU is located at the highest level, 0 otherwise Hence, the second lowest level (=± golden zone) = reference level
Context	Autonomy level	Autonomy = 1 if pickers can choose their next order, 0 otherwise
	Incentive system	Incentives = 1 if the rewards are group-based, 0 if individual-based
	Order assignment mechanism sequence	Sequence = 1 if pickers can choose their next order in the first session, 0 otherwise
	Number of preceding orders picked	Prior_orders [Number of preceding orders picked]
Picker	Length	Length [cm]
	Age	Age [years]
	Gender	Gender = 1 if the picker is female, 0 if male
	Educational level	Education = 1 if the picker is enrolled in one of the two most advanced programs within the school. The school hosts four possible education levels.

In order to mitigate the issue of correlated observations, we ran standard error-clustered regressions. Table 2 shows that the main effects of order factors 'Quantity' and 'L_2' are consistently significant over all models. The raw coefficients can be interpreted as the marginal contribution per additional unit of the independent variable to subjective discomfort, as the Borg CR-10 was designed in such a way as to allow for ratio calculations (Larco et al., 2017). The main effect of 'Unit_weight' is not significant; however, this is offset by its highly significant interaction effect with 'Quantity'. Almost no picker- and context factors significantly influence subjective physical well-being; only 'Prior_orders' is significant, despite the relatively short duration of the experiment. It is notable that the outcomes of model 4 are in line with those of models 1 to 3. Model 4 is a linear mixed-effects model with random intercepts at individual- and group-level, and thereby considerably more advanced than the three preceding models. We include this model as it is more suited to deal with the complex nature of our experimental data. In particular, it incorporates the unobserved heterogeneity among participants and prevents pseudoreplication due to correlated datapoints, which all add to the model's specification. Indeed, the $R^{2,conditional}$ of model 4 overshadows those of the preceding models, most likely due to large between-subjects variance. In addition, since we aim to assess the significance of all explanatory variables, we did not use a model with solely fixed effects, as time-constant variables would be removed due to multicollinearity. Besides that, the fourth model's findings are in line with those of the other models, which adds to the robustness of our outcomes.

Table 2. Regression model outcomes with Borg score as the dependent variable.

	Model 1	Model 2	Model 3	Model 4
(Intercept)	0.944 ***	1.267 ***	0.811	1.400
	(0.150)	(0.247)	(1.422)	(1.561)
Quantity	0.033 ***	0.033 ***	0.033 ***	0.035 ***
	(0.005)	(0.005)	(0.005)	(0.003)
Unit_weight	-0.019	-0.019	-0.022	-0.006
	(0.028)	(0.028)	(0.027)	(0.018)
Distance	-0.006	-0.005	-0.005	-0.005
	(0.008)	(0.008)	(0.008)	(0.006)
L_0	0.104	0.108	0.100	0.128 °
	(0.082)	(0.083)	(0.083)	(0.057)
L_1	-0.003	0.005	0.005	0.042
	(0.075)	(0.076)	(0.075)	(0.053)
L_2	0.216 **	0.220 **	0.216 **	0.266 ***
	(0.077)	(0.077)	(0.078)	(0.055)
Quantity*Unit_weight	0.291 ***	0.292 ***	0.293 ***	0.275 ***
	(0.030)	(0.029)	(0.029)	(0.018)
Autonomy		-0.060	-0.056	-0.037
		(0.057)	(0.057)	(0.036)
Incentives		0.019	0.013	-0.015
		(0.189)	(0.188)	(0.200)
Sequence		-0.328 °	-0.288	-0.330
		(0.189)	(0.199)	(0.208)
Prior_orders		-0.007 *	-0.007 **	-0.004 **
		(0.003)	(0.003)	(0.001)
Length			-0.004	-0.005
			(0.005)	(0.005)
Age			0.059	0.036
			(0.057)	(0.062)
Gender			-0.076	-0.153
			(0.277)	(0.329)
Education			0.227	0.083
			(0.227)	(0.253)
N (#individuals)	6055 (164)	6055 (164)	6055 (164)	6055 (164)
RE @ ind & group lvl	X	X	X	✓
R^2	0.244	0.252	0.257	$0.567^c/0.238^m$
R^2Adj	0.243	0.251	0.256	-
logLik	-12249.912	-12217.190	-12194.954	-10932.120
AIC	24517.820	24460.380	24423.910	21902.250
BIC	24578.200	24547.590	24537.950	22029.710

*** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$; ° $p < 0.1$. Standard errors are in parentheses.
^{c} = Conditional R^2; ^{m} = Marginal R^2.

5. DISCUSSION AND CONCLUSION

This study highlights the importance of order factors to contribute to subjective physical discomfort using an advanced and robust regression model with data from a large (N=164) and highly relevant sample. Our regression models also consider context- and picker factors, as recommended by prior research (Finco et al., 2023). However, those seem subordinate to order factors to predict physical well-being. The remainder of this section delves deeper into the regression outcomes and relates them to the prevailing convictions in current OP literature.

5.1 In-depth results discussion

The significant main effect of quantity corroborates earlier findings of Larco et al. (2017). Three underlying reasons may drive this significance. First, large product quantities imply a high degree of repetitiveness, i.e. standing still whilst counting. In that light, Wakula et al. (2021) have already indicated the favourable effects of alternating between walking and standing still for physical well-being. Second, participants did not use a picking cart in our experiment, which complicates the transport of multiple products, especially if those were of large volume. Manually transferring many products to the depot could therefore be perceived as physically challenging. Last, there might also be a halo effect at play. In particular, large quantities require considerable cognitive efforts as to not pick an incorrect number of products. Especially when one could not subitise, participants might have translated the additional cognitive efforts (and possible psychological discomfort due to frustrations) into physical discomfort.

The main effect of weight is not significant, although its interaction with quantity is, as depicted in Figure 3. This figure shows the effect of product quantity on perceived discomfort, depending on four levels of product weight (the maximum, 75% quartile, median, or minimum weight). The concrete βs to plot the linear functions are obtained from model 4 (see Table 2). For low-weight items, the incremental impact of quantity is rather limited. Conversely, heavy-weight items rapidly increase the perceived discomfort in ascending quantities. The bold red line represents the maximum Borg score (10). The W_{max} and $W_{q75\%}$ curves cross this line at a total weight of 36.07kg and 34.98kg respectively, well above the allowed weight limit of 25kg that exists in many Dutch warehouses. Nevertheless, Figure 3 illustrates the strong ergonomic impact of a select set of SKUs if multiple items are requested.

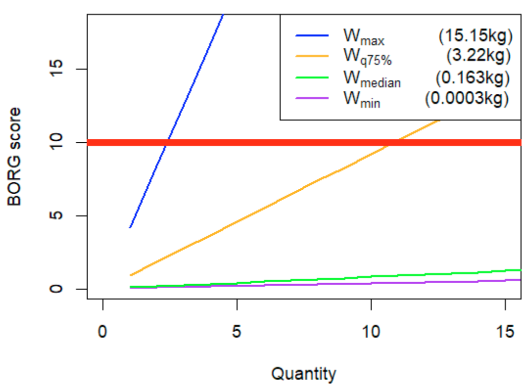

Figure 3. Visualisation of the interaction effect.

The rack level from which an SKU is picked also significantly contributes to subjective physical well-being. In particular, the lowest level requires pickers to bend over (or squat), while top-shelf picks induce pickers to stretch out and/or to tiptoe. In contrast to Battini et al. (2016), we find evidence that top-shelf picks are physically more demanding than bottom-shelf picks ($\beta_{L_0} < \beta_{L_2}$), at least in subjective terms. The study of Larco et al. (2017) partly endorses our finding, as one of their two experiments has similar results. Regardless of the effect size, it can be concluded that picking from extreme locations (in terms of height) negatively impacts physical well-being. In accordance, β_{L_1} is not significant. This is possibly due to the anthropometry of our subject, i.e. tall Dutch students, whose golden zone upper limit approximates the second-highest shelf height. Hence, there is a positive non-significant effect on Borg score.

Walking distance is the only order factor which is not significant. A possible explanation might be the relatively small dimensions of our lab warehouse. On the other hand, large real-world warehouses make use of trucks for internal transport. Therefore, our finding is still valid and translatable to these real-world settings. The minor ergonomic impact of walking is also shared by Calzavara et al. (2017), who trivialise the physical impact of travel efforts. As such, our study mitigates the concerns of Lavender et al. (2021) and refutes the suitability of walking distance to be an important driver of physical exertion, at least in settings like ours. Finally, our regression results do not show any consistently significant context- or picker factor, apart from 'Prior_orders'. This is a control variable whose significance indicates some kind of habituation. The negative effect size could be explained by the initial assimilation period during which pickers are highly critical about the exertion they perceive. After a while, pickers get accustomed to the strenuous work and depreciate the perceived discomfort. This effect might, however, tail off when work times exceed those of our experiment. Next, engaging pickers in the assignment of orders appears to be beneficial for physical well-being (negative $\beta_{Autonomy}$), albeit non-significantly. It is presumable that such a work design characteristic rather benefits psychological well-being than physical well-being. The non-significant influence of the picker factors is most likely due to the similar profiles and backgrounds of our sample subjects. A follow-up study with a more diverse study sample could shed another light and validate these presumptions.

5.2 Implications and conclusion

Many warehouses still heavily depend on human operators to carry out OP tasks. However, partly due to the strenuous and repetitive nature of OP, those people have become scarce. If warehouses want to remain competitive, human aspects should be considered when devising an efficient and sustainable OP system. This is especially true for the physical human factor since many warehouse workers are at serious risk of developing musculoskeletal disorders due to heavy loads and occasionally awkward body postures. Many research efforts have been devoted to objectively measuring the physical exertion to which order pickers are subjected. However, little is known about the factors that drive subjective physical well-being. This paper shows that mainly order properties and the physical warehouse design impact subjective well-being. The way in which the work is organised (e.g. prevailing incentive system, or worker participation) or picker properties are less relevant to predicting physical well-being.

Our insights and quantifications of subjective physical well-being pose several implications and opportunities for future research. First, the contemporary emphasis on automation across diverse industries entails the careful alignment of robotic and human workers. In the wake of Industry 4.0, many technological advancements have found their way to the warehousing sector. This allows to redistribute orders with the highest subjective physical discomfort to robots (or cobots). However, this practice leaves humans with an even more concise set of orders, possibly with very identical characteristics. As a consequence, this may induce monotony and could be detrimental to psychological well-being. A follow-up study could tap into our insights and those of Industry 5.0 to derive a sustainable redistribution scheme in which workers' preferences are included. Second, our study's quantification of subjective physical discomfort can serve as input for storage assignment decisions (e.g. Larco et al. (2017)) or workload balancing. For example, warehouses could adopt an optimisation model which ensures equal workload among workers. Concretely, our study has shown that the main determinants of subjective workload are product weight, picking height, and product quantity. Those factors could be the primary drivers of accurate workload balancing policies.

The findings of this study are subject to some limitations. The first limitation is the relatively short experimental duration. Although every participant had to pick for a total of 40 minutes, the long-term physical implications of order picking should not be overlooked. Subjects might perceive certain factors differently as the day progresses. A field study is therefore deemed to be more suitable, as it is virtually impossible to engage students for a long time during school hours. The students in our sample pose a second limitation, as they are all from the same school and age range, thus endangering generalisability. However, given our large sample size and highly relevant subjects, we are convinced that our sample includes a wide variety of individual traits. With the thorough examination of these picker factors, in conjunction with many context- and order factors, this study holistically explores the preconditions of an ergonomic OP system design. Operations Management can have a pronounced impact on well-being, provided that accurate data is fed into its models. With this study, we hope to provide the input which can pave the way for further human-centric research.

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