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Level of match between facial dimensions of Chilean workers and respirator fit test panels proposed by LANL and NIOSH

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ABSTRACT

The facial fit of respirators is crucial for determining how effectively respirators may protect users from exposure to airborne contaminants, when their use is required in the workplace. In the Chilean market, all the respirators available have been designed and manufactured using foreign regulations. The aim of this research was to determine the facial dimensions in a sample of Chilean workers (users or potential users of respiratory protective equipment) and the possible mismatch between their anthropometric characteristics and the respirator fit test panels proposed by Los Alamos National Laboratory (LANL) and National Institute for Occupational Safety and Health (NIOSH). An anthropometric survey that included 11 measurements was conducted, based on ISO/TS 16976–2 and ISO 15535 to ensure the highest standards possible, and a total of 474 workers (female: 229, male: 245), aged 18–66 years old participated in the survey. The anthropometric measurements were then contrasted with the fit test panels used in LANL (for half and full facepieces) and NIOSH (Bivariate and Principal component analysis (PCA)), to verify the level of mismatch. The results showed that LANL panels presented a level of mismatch of 11.8% and 21% for the half-facepiece and the full-facepiece, respectively. Considering the NIOSH bivariate and PCA panels, 4.6% and 4.4% of the sample remains without an assigned cell, respectively. It can be concluded that the LANL panels for half and full facepieces do not match the facial dimensions of the Chilean working population. The panels developed by NIOSH and considered by the ISO/TS 16976–2 (bivariate and PCA), are applicable to the Chilean working population.

Relevance for the Industry: This research provides anthropometric measurements of Chilean workers, to determine the dimensions for half- and full-facepiece respirators, which are currently not available. The NIOSH or ISO fit test panels, as opposed to LANL panels, should be used when manufacturing respirators for Chilean workers.

1. Introduction

With the ever-increasing role that protective equipment against air pollution has in society, facemasks and respirators have become an increasingly important part of our daily lives (Chen et al., 2015). Especially during these days, with the pandemic caused by Covid-19 and other viruses, where different requirements are published for civilians and for professional caregivers, which sometimes are different for each country. Ergonomic design has become ubiquitous in our society, and this trend is evident in design activities (Fan et al., 2019).

The facial fit of respirators is crucial for determining how effectively respirators may protect users from exposure to airborne contaminants, when their use is required in the workplace (Lee et al., 2016). Oestenstad and Bartolucci (2010) show some significant effects of the study factors on leaks using half-mask respirators, however the dimensions had a greater effect, and there were significant differences between the facial

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dimensions of subjects whose respirators presented leaks and of those who did not. This is also supported by Gao et al. (2016), who concluded that an improperly sized facepiece might potentially offer relatively low protection at high to strenuous workloads. Apart from the size, there are also problems caused by misuse of the facemask, such as touching the external side of it, taking it off when talking or using a phone, and using for prolonged amounts of time without washing or replacing it (Bakhit et al., 2020).

Mismatch means that the product does not fit the human and is presented when the anthropometric dimensions are either below the minimum or above the maximum limits of the product dimensions (Castellucci et al., 2016). In order to avoid the mismatch effect, National Institute for Occupational Safety and Health (NIOSH) requested the Los Alamos National Laboratory (LANL) in the 1970s the task of developing panels to represent 95% of the US working population (Hack and McConville, 1978) based on two facial dimensions: face length and face width for full face masks, and face length and lip length for half face masks. The dimensions of these fit test panels are based on anthropometric studies conducted in the late 1960s on a sample of male and female subjects from the US Air Force. Subsequently, Zhuang and Bradtmiller (2005) carried out a study with a sample of 3997 individuals, male and female civil workers, from different age groups (18–29, 30–44, 45–66 years) and four ethnic group strata (White, Black, Hispanic, and Others). The results of this investigation confirmed a low representation among the subjects measured for the LANL panels. Therefore, new adjustment panels for half- and full-facepiece respirators were developed and published in 2007 (Zhuang, Bradtmiller and Shaffer, 2007). The first of them was designed after a bivariate analysis of linear facial dimensions. The second panel was developed after an analysis of Principal Components Analysis (PCA) based on the 10 most representative facial dimensions of the totality of measurements. NIOSH's research was subsequently used as a reference for the elaboration of ISO/TS 16976-2 Respiratory Protective Devices- Human Factors- Part 2: Anthropometrics (ISO, 2015), which establishes, among other technical specifications, information related to human factors for the design of respirators.

Chile has little to no industrial production, mainly because the main sources of the country's income are commodities (from mining and agriculture). Therefore, a large number of products aimed at Chilean workers are manufactured overseas, mainly in China and Europe, and then are imported. As a result, it is likely to find a high level of mismatch between the products and Chilean workers' facial dimensions (Castellucci et al., 2019). In Chile, as in other countries, foreign technical standards are used to establish the technical requirements for respirators. Furthermore, the quality of respirators must be controlled and certified by entities authorized by the Chilean Institute of Public Health (ISP). However, the country currently does not have certification entities for respirators. In response to this, and in the absence of certification bodies, the ISP, in its role of national laboratory and reference for occupational health, implemented in 2009 the Register of Manufacturers and Importers (RMI) for Personal Protection Elements (PPE). This mechanism allows marketers to validate the quality certification that the PPE obtained abroad. The RMI has allowed the working population to be in possession of elements of PPE of certified quality, but of diverse origins (e.g. USA, Canada, China, Brazil, Argentina). Today all of the respirators available in the national market have been designed and manufactured using foreign regulations. As an example, until May 2020, 65.6% of half-face and full-face respirators incorporated into the RMI, are certified by NIOSH (United States) and 34.4% present other certifications (i.e. Europe) (ISP, 2020).

Considering the relevance of the mismatch between anthropometric dimensions and respirator dimensions, the aim of this paper is to determine the facial dimensions of Chilean workers (users or potential users of respiratory protective equipment) and the possible mismatch between the anthropometric characteristics of a sample of Chilean workers and the respirator fit test panels proposed by LANL and NIOSH.

Table 1
Estimated and real sample size.

Age Group	Female		Male		Total	
	Estimated	Real	Estimated	Real	Estimated	Real
18–37	110	119	110	134	220	253
38–66	110	110	110	111	220	221
Total	**220**	**229**	**220**	**245**	**440**	**474**

2. Methods and procedure

2.1. Sampling technique

Target population: The target population comprised all adult Chilean workers from the central region of the country (*Metropolitana* and *Libertador General Bernardo O'Higgins* Regions).

Sample: The sample consisted of a representative group of workers aged 18–66 years, who belonged to different branches of economic activity (Mining, Manufacturing, Electricity, Construction, Transport and Communications, Financial Services, and Communal and Personal Services). Workers were excluded from the sample if they presented a facial malformation, physical impediment to perform a quantitative fitting or presented abundant beard.

The sample considered a stratified design with two age groups (18–37 and 38–66) and two gender groups (Female and Male). The equal sample size for the four clusters was calculated using the principles defined in ISO 15535 (ISO, 2012). Thus, the minimum number of randomly sampled subjects, N (Eq. (1)), needed to ensure that the database's 5th and 95th percentiles represented the true population's 5th and 95th percentiles with 95% confidence (1.96). Furthermore, the sampling technique considered the desired percentage of relative accuracy (α) and the highest Coefficient of Variation (CV), which in this type of study considers the CV of the Menton-sellion length (face length).

$$N = \left(\frac{1.96 \times CV}{\alpha}\right)^2 \times 1.534^2 \quad (1)$$

Even though there are reference values for the CV such as 5.5 (Du et al., 2008) and 5.3 (Zhuang and Bradtmiller, 2005), the research team decided to perform a pilot measurement study to define the CV in Chilean workers. The study was conducted on 50 Chilean workers (between 18 and 66 years of age) and as an expected, face length presented the highest CV with a value of 5.2. Also, the α (desired percentage of relative accuracy) was set to 1.5%. Finally, after applying equation (2), the total sample size for each cluster was 110 workers (Table 1)

$$N = \left(\frac{1.96 \times 5.2}{1.5}\right)^2 \times 1.534^2 = 110 \quad (2)$$

2.2. Procedure before data collection

The measurement procedures were conducted by one survey team composed of three individuals, namely a marker, a measurer and a data recorder. The marker was responsible for the detection and marking of the anthropometric reference points on the subjects, the measurer was in charge of taking the measurements and the data recorder entered the data on a paper spreadsheet. Before the survey was initiated, the measurement team was trained by an expert in ergonomics and anthropometric for one week, mainly on the detection of head and nose reference points, and on anthropometric measurement procedures. After the training sessions, the evaluators proceeded to mark and measure the test subjects. Subsequently, the values were compared with the maximum error values allowed by NIOSH. Since the measurer error is the most troublesome source of anthropometric error and it can be accentuated by the use of multiple measurers (Viviani et al., 2018), for this study the survey team did not change roles during the entire evaluation process.

Table 2
Anthropometric dimensions considered in this study.

Anthropometric dimensions (mm)	Definition
1. Head breadth	Maximum horizontal breadth of the head as measured with a spreading caliper above the level of the ears. The subject sits looking straight ahead. Enough pressure is exerted to obtain contact between the caliper and the skin.
2. Minimum frontal breadth	The straight-line distance between the right and left frontotemporal landmarks on the temporal crest on each side of the forehead is measured with a spreading caliper. The subject sits looking straight ahead. Only enough pressure is exerted to ensure that the caliper tips are on the landmarks.
3. Face width	Maximum horizontal breadth of the face as measured with a spreading caliper between the zygomatic arches. The subject sits looking straight ahead and with teeth together (lightly occluded). Only enough pressure is exerted to ensure that the caliper tips are on the zygomatic arches.
4. Bigonial breadth	Straight-line distance measured with a spreading caliper between the right and left gonion landmarks on the corners of the jaw. The subject sits looking straight ahead and with teeth together (lightly occluded). Only enough pressure is exerted to ensure that the caliper tips are on the landmarks.
5. Nasal root breadth	The horizontal breadth of the nose at the level of the deepest depression in the root (sellion landmark) and at a depth equal to half the distance from the bridge of the nose to the eyes is measured with a sliding caliper. The subject sits looking straight ahead. The blunt points of the sliding caliper are used. Only enough pressure is exerted to obtain contact between the caliper and the skin.
6. Nose breadth	Straight-line distance as measured with a sliding caliper between the right and left alare landmarks. The subject sits looking straight ahead. Only enough pressure is exerted to obtain contact between the caliper and the skin
7. Subnasale-sellion length	Straight-line distance as measured with a sliding caliper between the subnasale landmark and the sellion landmark. The subject sits looking straight ahead. Only enough pressure is exerted to obtain contact between the caliper and the skin.
8. Face length	The distance in the midsagittal plane between the menton landmark at the bottom of the chin and the sellion landmark at the deepest point of the nasal root depression is measured with a sliding caliper. The subject sits looking straight ahead and with teeth together (lightly occluded). The fixed blade of the caliper is placed on the sellion. Only enough pressure is exerted to obtain contact between the caliper and the skin is exerted.
9. Nose protrusion	The straight-line distance between the pronasale landmark at the tip of the nose and the subnasale landmark under the nose is measured with a sliding caliper. The subject sits looking straight ahead. The sliding blade of the caliper is reversed and the base of the caliper is placed on the subnasale landmark. The beam of the caliper is parallel to the line of the protrusion of the nose.
10. Interpupillary distance	Distance as measured with a pupillometer at the center of the right and the center of the left pupil.
11. Lip length	The straight-line distance between the right and left chelion landmarks at the corners of the closed mouth is measured with a sliding caliper. The subject sits looking straight ahead with teeth together (lightly occluded). The facial muscles are relaxed, and the mouth is closed.

2.3. Data collection

The data collection process was approved by the Committee of Ethics at the Chilean Public Health Institute (*Instituto de Salud Pública de Chile*), dated August 20th, 2013, through Technical Report N°. 003-10SEP 2013. Written consent was obtained from the workers previous to the measurement procedures. The data collection was carried out from September 2013 to May 2016, and all the data were recorded in a paper spreadsheet and then entered into a software developed by NIOSH, which detects possible measurement or recording errors.

The anthropometric measurements were made with the subjects sitting in an erect position on a height-adjustable chair on a flat surface, with their legs flexed at a 90° angle, and with their feet flat on the floor or an adjustable footrest. During the measurement process, the subjects wore shoes and regular clothing.

Most of the anthropometric measurements were collected using a sliding caliper (GPM®, Switzerland) and the Interpupillary distance was measured with a pupillometer (Gilras, GR-4, China). The following anthropometric measures (ISO, 2015) were considered and collected during this study (Table 2, Fig. 1).

After data collection, the mean, minimum, and maximum values were calculated. As proposed in ISO 15535 (2012), the objective was to identify data outside the interval defined by the mean ± 3 standard deviations.

2.4. Statistical analysis

All anthropometric data were analyzed using MS Excel (v12.0.6787) and the SPSS statistical software (v17.0.0). The anthropometric key dimensions of face and head were contrasted with the LANL fit test panels (half-facepiece: face length and lip length; full-facepiece: face length and face width) and the NIOSH (Bivariate and PCA) fit test panels established by ISO based on the NIOSH studies, to verify the level of mismatch. Finally, an independent *t*-test (with a 95% confidence interval) was performed to examine the differences in measurements between genders.

3. Results and discussion

3.1. Sample

After checking the data for errors and performing the post-elimination process, a total sample of 474 volunteer workers was obtained (not randomly selected), which exceeded the estimated sample of 440 workers (Table 1). The descriptive statistics of the 11 anthropometric dimensions of the workers' population are presented in Table 3. As shown in Table 3, the average face length of females and males were 116.5 mm (SD: 5.6) and 127.2 mm (SD: 6.5), respectively, and the average face width of females and males were 132.7 mm (SD: 5.3) and 142.3 mm (SD: 6.6), respectively. As was expected, the obtained results showed that the male population presents higher dimensions than the female subjects. This difference between gender in the Chilean worker population was also reported in a recent anthropometric study of the Chilean population (Castellucci et al., 2019). Also, Lin and Chen (2017) present gender-specific differences in all 19 anthropometric dimensions gathered from 206 youths (Female: 105, Male: 101) representing respirator users in central Taiwan.

3.2. LANL panels

3.2.1. Bivariate half-facepiece

As shown in Table 4, the cells with the highest number of people were 8 and 10 with 26.2% and 24.5% respectively. These cells correspond to the upper right sector of the panel (Fig. 2). It is worth mentioning that 11.8% of the sample remained without an assigned cell. Furthermore, female subjects presented a higher level of match (96.9%) than male subjects (80%), these values are related to the fact that female subjects present lower key face dimensions (face length and lip length) than the male population (Table 4). Similar results were obtained by Yang et al. (2007) where the overall mismatch was 11.9%. However, the composition of mismatch by gender differs from the present study, where values of 8.2% and 14.5% were found for female and male

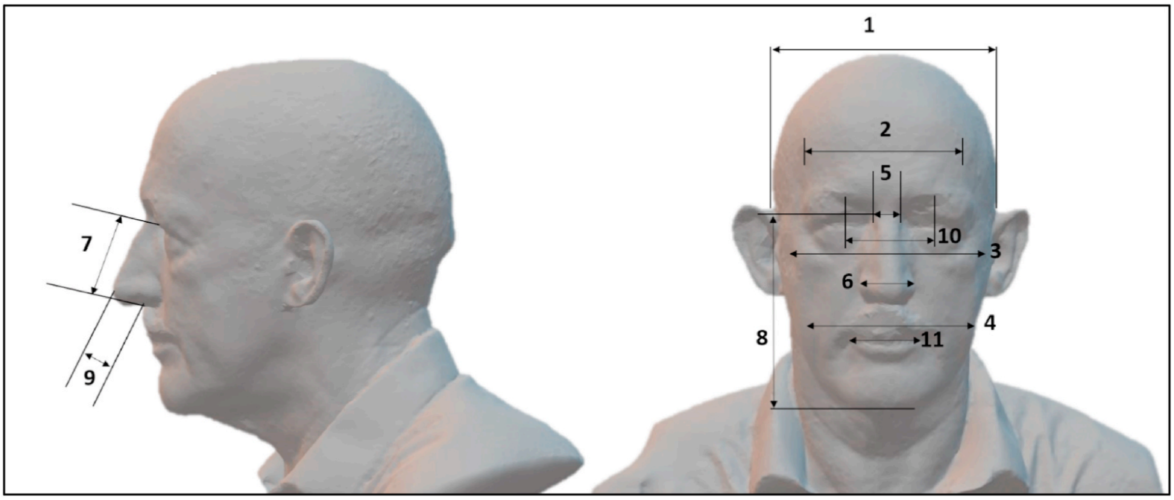

Fig. 1. Anthropometric measures considered in the study.
1. Head breadth, 2. Minimum frontal breadth, 3. Face width, 4. Bigonial breadth, 5. Nasal root breadth, 6. Nose breadth, 7. Subnasale-sellion length, 8. Face length, 9. Nose protrusion, 10. Interpupillary distance, 11. Lip length.

Table 3
Anthropometric measures of the considered sample.

Anthropometric dimensions (mm)	Male (n: 245)				Female (n: 229)			
	Mean	SD	P5	P95	Mean	SD	P5	P95
Head breadth°	154.5	5.7	145	164	147.4	5.2	139	155
Minimum frontal breadth°	100.4	5.1	92	109	95.6	5.5	88	105
Face width°	142.3	6.6	133	153	132.7	5.3	125	141
Bigonial breadth°	109.8	7.1	100	121	103.3	6.4	94	115
Nasal root breadth°	18.9	2.4	15	23	18.2	2.2	15	22
Nose breadth°	38.3	3.2	34	43	33.9	2.7	30	39
Subnasale-sellion length°	55.2	4.1	49	62	51.2	3.4	46	57
Face length°	127.2	6.5	117	139	116.5	5.6	107	126
Nose protrusion°	19.1	2.5	15	23	17.2	2.3	14	21
Interpupillary distance°	61.0	3.1	56	67	60.0	2.8	56	65
Lip length°	55.7	4.1	49	63	52.7	3.7	46	59

° $p < 0.01$.

Table 4
Number and Percentage of Chilean workers for the respirator fit panels by the LANL and NIOSH.

Cell	LANL						NIOSH					
	Bivariate half-facepiece			Bivariate full-facepiece			Bivariate			PCA		
	Female	Male	Total	Female	Male	Total	Female	Male	Total	Female	Male	Total
1	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	9 (3.9)	0 (0)	9 (1.9)	85 (37.1)	2 (0.8)	87 (18.4)
2	2 (0.8)	0 (0)	2 (0.4)	3 (1.3)	0 (0)	3 (0.6)	3 (1.3)	0 (0)	3 (0.6)	63 (27.5)	10 (4.1)	73 (15.4)
3	0 (0)	0 (0)	0 (0)	9 (3.9)	0 (0)	9 (1.9)	70 (30.1)	2 (0.8)	72 (15.2)	6 (2.6)	1 (0.4)	7 (1.5)
4	35 (15.3)	2 (0.8)	37 (7.8)	42 (18.3)	2 (0.8)	44 (9.3)	61 (26.6)	11 (4.5)	72 (15.2)	17 (7.4)	13 (5.3)	30 (6.3)
5	22 (9.6)	9 (3.7)	31 (6.5)	9 (3.9)	3 (1.2)	12 (2.5)	1 (0.4)	4 (1.6)	5 (1.1)	27 (11.8)	51 (20.8)	78 (16.5)
6	1 (0.4)	0 (0)	1 (0.2)	73 (31.9)	11 (4.5)	84 (17.7)	43 (18.8)	22 (9)	65 (13.7)	24 (10.5)	88 (35.9)	112 (23.6)
7	57 (24.9)	8 (3.3)	65 (13.7)	47 (20.5)	29 (11.8)	76 (16.0)	36 (15.7)	83 (33.9)	119 (25.1)	4 (1.7)	45 (18.4)	49 (10.3)
8	58 (25.4)	66 (26.8)	124 (26.2)	1 (0.4)	19 (7.8)	20 (4.2)	0 (0)	32 (13.1)	32 (6.8)	0 (0)	17 (6.9)	17 (3.6)
9	11 (4.8)	31 (12.7)	42 (8.9)	12 (5.2)	67 (27.3)	79 (16.7)	2 (2.6)	51 (20.8)	53 (11.2)	——	——	——
10	36 (15.7)	80 (32.7)	116 (24.5)	0 (0)	48 (19.6)	48 (10.1)	0 (0)	22 (9)	22 (4.6)	——	——	——
Total	**222 (96.9)**	**196 (80.0)**	**418 (88.2)**	**196 (85.6)**	**179 (73.0)**	**375 (79.0)**	**225 (98.2)**	**227 (92.7)**	**452 (95.4)**	**226 (98.6)**	**227 (92.6)**	**453 (95.6)**

subjects, respectively.

3.2.2. *Bivariate full-facepiece*

Regarding the LANL bivariate full-facepiece, from Table 4 it can be stated that the cells with the highest number of people were 6, 7 and 9 with 18%, 17% and 16%, respectively. These cells correspond to the upper left sector of the panel (Fig. 3). It is important to mention that 21% of the sample remained without an assigned cell, regarding the bivariate full-facepiece panel proposed by LANL. The subjects from the Chilean sample had larger key face dimensions (face length and face width) than the military population used to develop the LANL panels. Similar results were presented by Zhuang et al. (2007), since the LANL full-facepiece panel excluded 15.3% of NIOSH survey subjects. Finally, higher levels of mismatch were obtained from Yang et al. (2007), where 34.9% of the

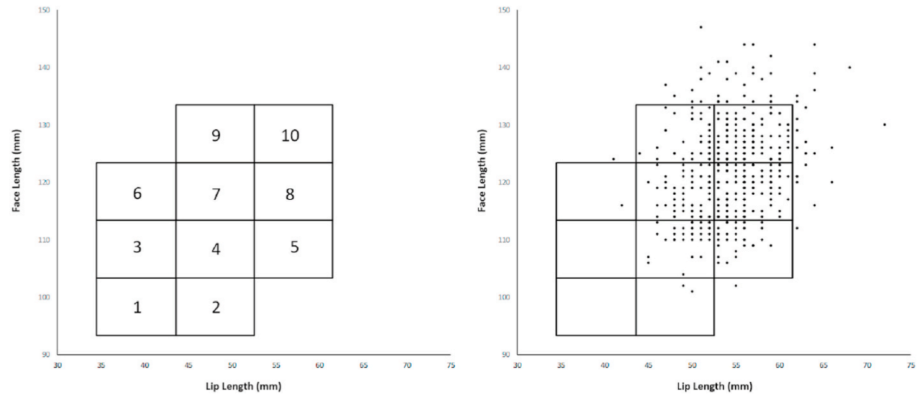

Fig. 2. Bivariate distribution of the sample with the LANL Bivariate half-facepiece panel.

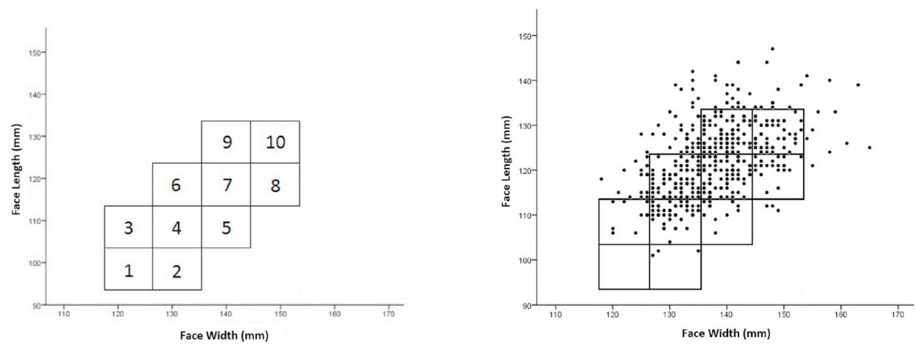

Fig. 3. Bivariate distribution of the sample with the LANL Bivariate full-facepiece panel.

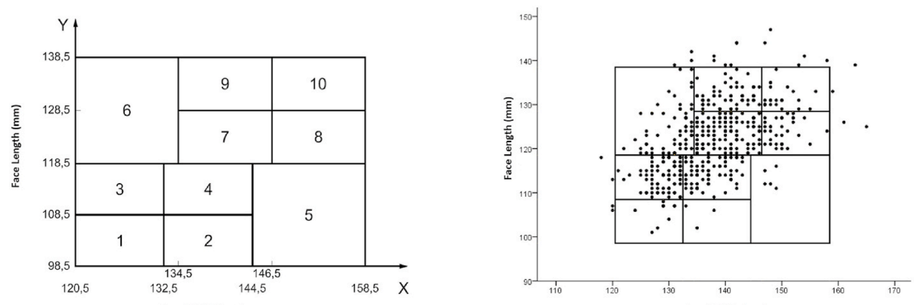

Fig. 4. Bivariate distribution of the sample with the NIOSH Bivariate panel.

461 university students and teachers from Zhongyuan University of Technology and Donghua University didn't match the LANL panel.

3.3. NIOSH panel

3.3.1. Bivariate

The frequency obtained in each of the cells and the relative percentage of that frequency for the total sample are presented in Table 4. It can be observed that the overall match is 95.4% and the cell with the highest number of workers was cell 7 with 25.1% of the sample. Moreover, cells 3 and 4 contain 15.2% each. As can be seen in Fig. 4, workers are mainly scattered at the central section of the bivariate panel. Considering the NIOSH bivariate panel and the face classification (Zhuang et al., 2008), most of the study participants had medium face size (55.1%, Cells 4–7), followed by 27.4% who presented large faces (cells 8–10) and the remaining 17.5%, who presented small face size (cells 1–3).

A lower level of overall match (85.5%) was obtained by Yang et al. (2007) with a sample of 461 university students and teachers from China. In said study, the cells with the highest number of workers were cells 5, 2 and 4 with 22.1%, 18.7 and 17.8 respectively. These results could be related to the wider and shorter faces from the Chinese sample, compared to the American sample used to develop the NIOSH panels. However, Chen et al. (2009), who used a sample of 3000 Chinese subjects (2026 males and 974 females) with three age groups (18–29, 30–44 and 45–66 years) and two gender groups (male and female), shows an overall match of 96.4% and the cells with the highest number of workers were cells 5, 4 and 2 with 26.9%, 25.9 and 16.3 respectively.

3.3.2. Principal component analysis (PCA) panel

Several statistical approaches have been used as fitting criteria in research involving multivariate applications to transform anthropometric data into design parameters. Principal component analysis (PCA), which groups many measurement variables into a small set depending on their significance of correlation or covariance, is the most commonly used approach (Dianat et al., 2018). This analysis consisted of observing

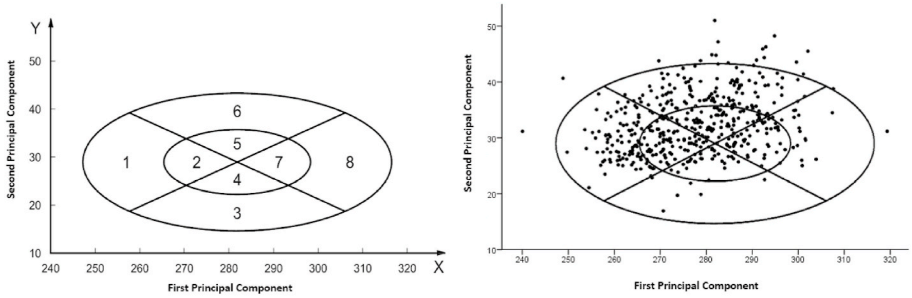

Fig. 5. PCA distribution of the sample with the NIOSH PCA panel.

the distribution of the Chilean sample using the Eigenvectors from PCA applied to U.S. working population (Zhuang et al., 2007). Regarding the classification of the Chilean sample, from Table 4 it can be observed that the PCA presented the highest level of overall match (95.6%) and a match of 98.6% and 92.6% for female and male subjects, respectively. Similar result were found in the study by Chen et al. (2009) with an overall match of 95.9%, and a better distribution of matches by gender (Female 96.9%, male 94.8%). Considering face sizes (Zhuang et al., 2008), it is important to mention that 48.5% of the population presented medium face size (cells 2, 4, 5, 7), followed by 23.6% with long/narrow face size (cell 6), 18.4% with small face size (cell 1), 3.6% with large face size (cell 8) and the remaining 1.5% belongs to short/wide face size (cell 3) (Fig. 5).

The present study demonstrates that for the Chilean sample the NIOSH panels present a higher level of match than the LANL panels (Table 4). As was previously mentioned, the NIOSH panels are currently proposed by the ISO/TS 16976–2 (ISO, 2015). This standard suggests that the bivariate panel based on face width and length should at least cover 95% of the population. Also state that in the selected population, the panel covers 96.7% of male and 98.7% of female subjects, however in the Chilean sample this panel includes 92.7% of men and 98.2% of women (Table 4). This result shows a good compliance for the Chilean female but a 4% risk for the Chilean male population in comparison with the standard.

Furthermore, the same trend could be observed for the PCA panel (Fig. 5), since the ISO/TS 16976–2 (ISO, 2015) suggests that the ellipse of this panel should include 95.3% of men and 97.6% of women, or at least 95% of the studied population. Considering the previous information, it could be stated that this is only partially met, since 92.6% of the men match the dimensions proposed. On the other hand, 98.6% of the women are covered by the dimensions proposed by the PCA panels, and when we look at the mixed population (50%male+50%female) there is a 95.6% compliance with the standard.

In order to protect the Chilean worker population, it is very important that authorities in Chile only consider respirators that are manufactured using the NIOSH panels (also considered by ISO) instead of respirators developed or certified based on the LANL panels. This recommendation may be temporarily applicable, since the male Chilean worker population could be underrepresented by the bivariate and PCA NIOSH panels.

Finally, it is also important to acknowledge some limitations of this work. The sample size could have been larger and including more regions of Chile. Broadly speaking, more detailed anthropometric surveys require more resources and time. Thus, in developing countries such as Chile, this presents an additional challenge, especially considering Chile's particular geographical characteristics – its length of 4000 km, which is equal to the distance from the north of Norway to south of Spain (entire Europe)–, which makes the cost of implementing a nationwide anthropometric survey very high.

4. Conclusion

Considering the results found in the present study, it can be concluded that the LANL panels for half and full facepieces do not match the facial dimensions of Chilean workers. The panels developed by the NIOSH and considered by the ISO/TS 16976–2:2015 (bivariate and PCA), are applicable to the Chilean working population. Furthermore, it is suggested that the present sample is expanded, to comply with the ISO/TS 16976–2: 2015.

CRediT authorship contribution statement

Ariel Antonio Rodríguez: Project administration, Conceptualization, Methodology, Investigation, Writing - review & editing. **David Eduardo Escanilla:** Methodology, Investigation. **Luis Alberto Caroca:** Conceptualization, Methodology, Investigation, Writing - review & editing. **Christian Eduardo Albornoz:** Methodology, Investigation. **Paulina Andrea Marshall:** Methodology, Formal analysis. **Johan F.M. Molenbroek:** Validation, Visualization, Writing - review & editing. **Héctor Ignacio Castellucci:** Formal analysis, Writing - original draft.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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