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ORIGINAL RESEARCH

Analysis of the Microbiota of the Physiotherapist's Environment

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Abstract

Objectives: To analyze the microbiota of the physiotherapist's work environment to understand the existing potential risks and to adopt appropriate preventive measures.

Design: Cross-sectional descriptive observational study.

Setting: Physiotherapist's working environment.

Participants: Physiotherapy and rehabilitation centers (N = 19).

Interventions: A microbiological sampling was carried out in the physiotherapy centers. The samples were studied using the usual culture and analysis methodology for characterization and isolation of a range of bacteria.

Main Outcome Measures: Absolute and relative frequency of microorganism isolation.

Results: In the analysis, pathogens normally responsible for nosocomial infections were detected, especially on instruments and equipment used by the physiotherapist such as sponge electrodes, and were significantly more contaminated than the rest of the places studied ($P<.01$).

Conclusion: This situation confirms the absence of measures and protocols for the prevention and control of such infections in the physiotherapist's environment, which is why they must be considered to protect both physiotherapy professionals and patients.

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According to the data reported for the Study of Prevalence of Nosocomial Infections in Spain for the year 2016, the prevalence of nosocomial infections stood at 5.5% in hospital rehabilitation services, placing it fourth in the ranking, just behind surgical specialties.[1] These particular types of infection often affect geriatric patients, children, and people with chronic diseases, all of whom are susceptible to acquiring infections within the hospital environment. Several factors that may be related to the high prevalence of nosocomial infections have been identified, including the current trend of starting the rehabilitation process at an early stage (even after a stay in an intensive care unit); difficulties in the isolation of patients susceptible to infection; heterogeneity in training among professionals in infection control interacting in these units; and the use of instruments and equipment whose handling, maintenance, and cleaning is frequently not included in the prevention protocols of nosocomial disease transmission.[2-10]

Previous investigations have been conducted to determine the microbiological contamination of the equipment and materials routinely used in physiotherapy, such as ultrasonic devices and therapy machines.[11-14] However, studies related to microbiological hazards that may occur in the physiotherapeutic environment are scarce both in our country and much of the Western world.[9,15]

At present, there are no specific recommendations for the management and infection control in the physiotherapist's environment based on objective data, despite calls to do so in the past by various authors.[2] Therefore, the objective of this study was to discover the bacterial microbiota present in the physiotherapeutic environment in order to detect potential risks of nosocomial infections.

Methods

Design

A cross-sectional descriptive observational study was proposed to analyze the nosocomial bacterial microbiota present in the work environment of the physiotherapist.

Disclosures: none.

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Participants

Nineteen physiotherapy centers were selected for this investigation. Permission for the sampling was requested from the management or owners of the centers, and they were instructed not to inform the personnel of the time of the visit for the collection of samples to prevent influencing the behavior of the workers in the center. In each center, samples were collected from the treatment couches, the instruments and equipment being used, from the hands of the physiotherapists, and the ambient air. All samples were classified and numbered as shown in table 1.

Intervention

The collection of samples was carried out using 3 methods depending on the characteristics of the study site. With the exception of the samples taken from the ultrasound gel and the ambient air, a sterile swab with Copan Venturi Transystem[a] transport medium was used. Each swab was handled individually using non-sterile vinyl gloves, the container was opened immediately before the collection of the sample, and the swab applicator was placed immediately and directly into the tube containing the transport medium without touching any external surfaces. For samples of ultrasound gel, a 5 cm^3 sterile syringe was used for the extraction of 1 cm^3 of gel from the container next to the therapeutic ultrasound equipment. Once the sample was taken, the extraction cannula of the syringe was sealed with the needle cap to avoid contamination during transport until the time of culturing. Finally, the collection of environmental air was done by collecting 250 liters of air directly onto a Petri dish with cysteine lactose electrolyte deficient agar, using an impactor device for taking aerial samples on standard 90 mm plates (MAS-100; Merck Millipore[b]). All samples were labeled for correct follow-up and were transferred to the laboratory under cold conditions in a portable refrigerator for a period not exceeding 24 hours.

Once in the laboratory, the samples were aseptically plated on Difco[c] prepared plates with the following solid culture media: blood agar, Baird-Parker agar, MacConkey agar, Mossel agar, and King B agar. The semisolid culture medium GI was used for the detection of bacterial motility. The plates were incubated at 37°C±1°C for a period of 24 hours. Thereafter, the plates were checked for the presence of colony-forming units. Identification of colonies was made through observational methods (ie, Gram stain negative and direct microscopic observation), biochemical tests (ie, catalase test and oxidase test), tests using miniaturized selected BBL Enterotube II[d] galleries for the identification of Enterobacteriaceae and other Gram-negative bacilli with negative oxidase results, and BBL Oxi/Ferm Tube II[d] for the detection of Gram-negative fermenting bacteria positive for oxidase and non-fermenting Gram-negative bacteria. After characterization of samples using the house commercial systems bioMérieux Vitek[e] with gallery ATB STAPH 5 was used for the detection of staphylococci, and Vitek 2 Compact (applying the cards ID-GNB, ID-GPC, ID-NH) was used to identify Gram-negative bacilli, Gram-positive coccus, and *Neisseria-Haemophilus*, respectively.

Data analysis

All data obtained from the samples, respecting the confidentiality of their origin, were used and processed using the statistical analysis software SPSS (version 15.0)[f] and Statgraphics (version 5.1),[g] in addition to Microsoft Excel 2007[h] for the preparation of graphs and calculation tables.

The relative and absolute frequencies were calculated, and the value of the Spearman correlation coefficient between the grouping categories of the centers was calculated according to (1) their average daily care load, (2) the ownership of the center, and (3) their type of care (ambulatory or integrated into an organization with hospitalization of patients) versus the frequency of contamination of the samples and number of contaminating colonies. Analysis of variance was also performed on the total number of colonies in the 4 groups of samples analyzed. Finally, the differences between the total number of contaminated colonies with group B samples were analyzed using the Student *t* test to compare the incidence of contamination between certain instruments and equipment.

Results

Not all of the originally proposed samples to be obtained from each center could be collected because of the different characteristics and work modes normally used in the physiotherapy centers. Of the 247 potential samples, a total of 201 were collected. Of these, 83 were positive in growth after cultivation. The presence and distribution in the appearance of the species found was variable. Their absolute and relative frequencies are shown in tables 2 and 3.

The Spearman rank correlation coefficient was established by clustering the centers according to their average daily care load (0-50 patients/d, 50-100 patients/d, and 100-200 patients/d) , and the frequency of contamination of the samples. The ownership (privately or publicly owned), character of the center (centers with outpatient admission or centers with inpatients), and the frequency of contamination of the samples was also established. There was no correlation for a *P* value less than .05 in any of the cases.

The use of analysis of variance (table 4), showed there were significant differences between the different types of samples (differences between groups) with a *P* value less than .01. The least significant difference test indicated that the differences were proven ($P<.05$) between the B samples (instruments), which

Table 1 Criterion for collection and numbering of the samples

Sample Groups	Samples
Treatment table, A	
1	Head section
2	Intermediate section
3	Caudal section
Instruments and equipment, B	
1	Reusable sponge electrodes
2	Adhesive reusable electrode
3	Single use adhesive electrode
4	Ultrasound probe
5	Ultrasound gel
6	Short-wave electrodes
7	Laser probe
8	Cold packs
Physiotherapist, C	Hands
Ambient air, D	250 liters of ambient air

Table 2 Absolute frequency of microorganism isolated from the samples studied

Sample Type																								
												Species												
Sample Group A				Valid Samples			S.ep	C.fr	P.ag	A.b	St.m	S.au	S.s	Mc	M.ca	Aer	C.l	P.ae	P.nae	D.n	P.neu	K.r	P.m	S.ho
Head section of treatment table				19			4	1	–	–	–	–	–	–	–	1	–	–	1	2	1	1	–	1
Intermediate section of treatment table				19			2	–	1	1	–	–	1	–	–	–	–	–	–	–	–	–	1	–
Caudal section of treatment table				19			3	–	–	1	1	1	–	1	1	1	1	1	1	–	–	1	–	–
Total				57			9	1	1	2	1	1	1	1	1	2	1	1	2	2	1	2	1	1
Sample Group B		S.ep	C.fr	P.ag	A.b	St.m	S.au	A.l	Mc	M.ca	Aer	Flv	P.ae	P.nae	Pr.s	Ser.r	K.r	S.hy	S.ho	Ser.m	S.int	Bac	C.br	E.col
Sponge electrode	\	5	3	3	2	1	1	4	–	1	1	2	1	–	1	1	1	1	1	1	1	1	1	1
Adhesive reusable electrode	12	–	1	1	2	–	–	–	–	–	–	1	–	–	1	–	–	–	–	–	–	–	–	–
Single use adhesive electrode	7	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Ultrasound probe	17	1	–	–	–	–	1	–	1	–	–	–	–	–	–	–	–	–	–	–	–	2	–	–
Ultrasound gel	17	–	–	1	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Short-wave electrodes	13	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Laser probe	9	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Cold packs	15	–	–	–	–	1	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	1	–	–
Total	107	6	4	5	4	3	2	4	2	1	1	3	1	1	2	1	1	1	1	1	1	4	1	1
Sample Group C								S.ep				Bac				Mc				Cor				St.m
Physiotherapist's hands				18				5				5				4				1				1
Sample Group D											S.ep							Mc						Bac
Ambient air					19						4							7						2

Abbreviations. A.l, Acinetobacter lwoffii; A.b, Acinetobacter baumannii; Aer, Aeromonas spp.; Bac, Bacillus spp.; C.l, Cedecea lapagei; C.br, Citrobacter braakii; C.fr, Citrobacter freundii; Cor, Corynebacterium spp; D.n, Dermacoccus nishinomiyaensis; E.col, Escherichia coli; Flv, Flavobacterium spp.; K.r, Kocuria rosea; Mc, Micrococcus spp.; M.ca, Moraxella catarrhalis; P.ae, Pseudomonas aeruginosa; P.ag, Pantoea agglomerans; P.m, Pasteurella multocida; P.nae, Pseudomonas no aeruginosa spp.; P.neu, Pasteurella pneumotropica; Pr.s, Providencia stuartii; S.au, Staphylococcus aureus; S.ep, Staphylococcus epidermidis; Ser.m, Serratia marcescens; Ser.r, Serratia rubidaea; S.ho, Staphylococcus hominis; S.hy, Staphylococcus hyicus; S.int, Staphylococcus intermedius; S.s, Staphylococcus sciuri; St.m, Stenotrophomonas maltophilia.

Table 3 Relative frequency of microorganism isolated from the samples studied, expressed as percentages

Sample Type		Species																			
Sample Group A	Valid Samples	S.ep	C.fr	P.ag	A.b	St.m	S.au	S.s	Mc	M.ca	Aer	C.l	P.ae	P.nae	D.n	P.neu	K.r	P.m	S.ho		
Head section of treatment table	19	21.0	5.3	—	—	—	—	—	—	—	5.3	—	—	5.3	10.5	5.3	5.3	—	5.3		
Intermediate section of treatment table	19	10.5	—	5.3	5.3	—	—	5.3	—	—	—	—	—	—	—	—	—	5.3	—		
Caudal section of treatment table	19	15.8	—	—	5.3	5.3	5.3	—	5.3	5.3	5.3	5.3	5.3	5.3	—	—	5.3	—	—		
Total	57	15.8	1.7	1.7	3.5	1.7	1.7	1.7	1.7	1.7	3.5	1.7	1.7	3.5	3.5	1.7	3.5	1.7	1.7		
Sample Group B		S.ep	C.fr	P.ag	A.b	St.m	S.au	A.l	Mc	M.ca	Aer	Flv	P.ae	P.nae	Pr.s	Ser.r	K.r	S.hy	S.ho	Ser.m	S.int	Bac	C.br	E. col
Sponge electrode	17	29.4	17.6	17.6	11.8	5.9	5.9	23,5	—	5.9	5.9	11.8	5.9	—	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9
Adhesive reusable electrode	12	—	8.3	8.3	16.7	—	—	—	—	—	—	8.3	—	—	8.3	—	—	—	—	—	—	—	—	—
Single use adhesive electrode	7	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Ultrasound probe	17	5.9	—	—	—	—	5.9	—	5.9	—	—	—	—	—	—	—	—	—	—	—	—	11.8	—	—
Ultrasound gel	17	—	—	5.9	—	5.9	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Short-wave electrodes	13	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Laser probe	9	—	—	—	—	—	—	—	11.1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Cold packs	15	—	—	—	—	6.7	—	—	—	—	—	—	—	6.7	—	—	—	—	—	—	—	6.7	—	—
Total	107	5.6	3.7	4.6	3.7	2.8	1.9	3.7	1.9	0.9	0.9	2.8	0.9	0.9	1.9	0.9	0.9	0.9	0.9	0.9	0.9	3.7	0.9	0.9
Sample Group C		S.ep					Bac				Mc					Cor					St.m			
Phyisiotherapist's hands	18	27.8					27.8				22.2					5.5					5.5			
Sample Group D		S.ep									Mc										Bac			
Ambient air	19	21.0									36.8										10.5			

Abbreviations. A.l, Acinetobacter lwoffii; A.b, Acinetobacter baumannii; Aer, Aeromonas spp.; Bac, Bacillus spp.; C.l, Cedecea lapagei; C.br, Citrobacter braakii; C.fr, Citrobacter freundii; Cor, Corynebacterium spp; D.n, Dermacoccus nishinomiyaensis; E.col, Escherichia coli; Flv, Flavobacterium spp.; K.r, Kocuria rosea; Mc, Micrococcus spp.; M.ca, Moraxella catarrhalis; P.ae, Pseudomonas aeruginosa; P.ag, Pantoea agglomerans; P.m, Pasteurella multocida; P.nae, Pseudomonas no aeruginosa spp.; P.neu, Pasteurella pneumotropica; Pr.s, Providencia stuartii; S.au, Staphylococcus aureus; S.ep, Staphylococcus epidermidis; Ser.m, Serratia marcescens; Ser.r, Serratia rubidaea; S.ho, Staphylococcus hominis; S.hy, Staphylococcus hyicus; S.int, Staphylococcus intermedius; S.s, Staphylococcus sciuri; St.m, Stenotrophomonas maltophilia.

Table 4 Results of the analysis of the variance and the Student *t* test on the Group B samples (instruments)

ANOVA					*P* Value
Differences between groups					$P<.01$
Intra-group differences					NS
LSD Between Sample Types		D		C	B
A		NS		NS	$P<.05$
B		$P<.05$		$P<.05$	
C		NS			
Student *t* Test	B2	B4	B5	B7	B8
B1					
P value	NS ($P=.186$)	$P=5.298\times10^{-10}$	$P=.002$	$P=4.402\times10^{-5}$	$P=3.528\times10^{-4}$

NOTE. B3 and B6 samples are not included because no microbiological contamination was found in these fomites.
Abbreviations: ANOVA, analysis of variance; LSD, least significant difference; NS, not significant.

would be the most contaminated, and the rest of the samples. The result of the Student *t* test (see table 4) on the samples obtained from B1 (sponge electrodes) showed greater contamination than the rest of the group B samples, with a 99% probability ($P<.01$) compared with B4, B5, B7, and B8 samples (ultrasound probe, ultrasound gel, laser probe, and cryotherapy bags, respectively), and an 84% probability ($P<.16$, not significant) compared with B2 samples (reusable adhesive electrodes).

Discussion

Considering the relative and absolute frequencies of isolation of microorganisms (see tables 2 and 3), it can be affirmed that there was a greater presence of coagulase-negative staphylococci, and Gram-negative non-Enterobacteriaceae bacteria on treatment couches or tables where patients are treated (A samples), which is in agreement with the studies by Kim et al[9] and Kim et al,[15] who also found significant contamination by these types of microorganisms. Other authors have studied the treatment tables exclusively in their work and have also found a higher presence of Gram-positive bacteria, especially species of coagulase-negative *Staphylococcus*.[16] It should be noted that in all of the studies cited, except for that conducted by Burnham et al,[17] the presence of *S. aureus* was low, which agrees with the findings of this study (see tables 2 and 3). Regarding the type of contamination between the 3 sections evaluated (head, intermediate, and caudal sections), there were no large differences observed with coagulase-negative *S.* spp. being predominant in all of them, a fact that is novel as there are no such data in the existing literature.

In the samples from group B, which were taken from various instruments commonly used in the physiotherapy room, a greater presence of Enterobacteriaceae bacteria was found, including species such as *Pantoea agglomerans*, *Citrobacter freundii*, *Serratia marcescens*, *Serratia rubidaea*, and *Providencia stuartii*. A significant presence of *S. epidermidis* was also detected. The samples obtained from group B were significantly more contaminated ($P<.05$) than the rest of the group of samples. The samples obtained from the sponge electrode (B1) presented higher and more varied contamination compared with the other samples ($P<.01$ for samples B4, B5, B7, and B8) (see table 4). These data indicate that the sponge electrode is a major source of microorganisms among the instruments evaluated, with more than 20 different bacterial species identified (see table 2, fig 1), including important pathogens such as *S. aureus*, *Acinetobacter* spp., and *Escherichia coli*. The identification of this type of electrode as the main source of microorganisms is concordant with the study by Kim et al,[9] although most of the microorganisms identified in their study were non-Enterobacteriaceae Gram-negative bacteria (*Acinetobacter baumannii*, *Acinetobacter lwoffii*, and *Acinetobacter junii*). On the other hand, in their investigations of sponge electrodes, Lambert et al[11] found a predominance of negative coagulase *Staphylococcus* and other Gram-negative species (*Acinetobacter* spp., *Pasteurella* spp., and *Pseudomonas* spp.). In this latter case, there was greater agreement with the results of the present study in relation to the high presence of negative *coagulase Staphylococcus*.

Among the group B samples evaluated in this investigation, other instruments and equipment previously investigated were also studied, such as the probe (sample B4) and the ultrasound gel (sample B5). The study by Schabrun et al[12] found that these devices were contaminated to a greater percentage with negative coagulase *Staphylococcus*, followed by *Micrococcus* spp., and certain environmental species of fungi. We found that the ultrasound heads had a lower presence of Gram-positive bacteria (*Bacillus* spp. and *Micrococcus* spp.) but *S. epidermidis* and *S. aureus* were also detected in isolation. As for the transduction ultrasound gel, small amounts (<5 colony-forming units/cm^2) isolated from *P. agglomerans*, *Stenotrophomonas maltophilia*

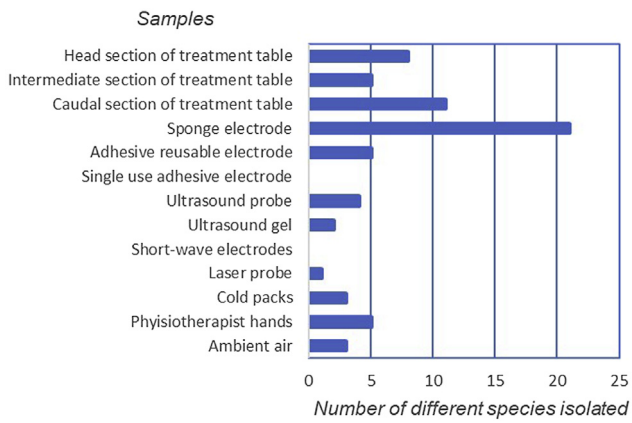

Fig 1 Total number of different species isolated in each type of sample.

were found. In contrast, the study by Schabrun et al[12] detected high concentrations of *S. maltophilia* and *A. baumannii* in the samples analyzed.

The microorganisms detected on the hands of the physiotherapists (C samples), were mostly Gram-positive bacteria, in keeping with the usual microbiota of the human body.[18] Specifically, *S. maltophilia* and *Corynebacterium* spp. were detected. This fact reinforces the necessity of hand washing before touching the patient, and even combining hand washing with the use of gloves. Furthermore, it is necessary to wash properly after touching the patient to avoid cross contamination.

Finally, only *S. epidermidis*, *Micrococcus* spp., and *Bacillus* spp. were detected in the air samples from the centers, as well as fungi that were not isolated or identified as they were not the aim of this work. The presence of fungal spores as the main contaminant is also consistent with normal atmospheric conditions.[19]

The absence of Enterobacteriaceae bacteria in the hand and air samples, along with the predominant presence of these microorganisms in B samples (especially the sponge electrodes [B1]), suggest that the transmission routes of these microorganisms are not attributable to the atmosphere or to the clinical staff. These microorganisms appear mainly in wastewater because they are part of the intestinal microbiota of mammals. Thus, fecal-oral transmission is the probable predominant route. Although the contaminant load of these bacteria is low, conditions of humidity, temperature, and the presence of organic remains, combined with poor hygiene practices with the sponge electrode, may favor their growth, which would explain the abundance of microorganisms found. In most of the literature consulted on the use, application, and conservation of sponge electrodes, there are no specific protocols for their disinfection and cleaning.[20] The lack of sanitation behavior for this type of electrode is striking, especially when some texts recommend the direct application of the electrode on ulcers and scars, with only the interposition of a saline-moistened pad.[21]

The absence of adequate cleaning and maintenance entails the accumulation and proliferation of nosocomial pathogens detected during this study in several of the fomites analyzed, among which are coagulase-positive staphylococci, Enterobacteriaceae bacteria, and *Pseudomonas* spp.[22-24] The pathogenic action of many of these microorganisms has been exacerbated in recent years by the increasing frequency of antibiotic resistance, which affects a greater number of species.[25-30]

The importance of maintaining good hygiene and disinfection measures in physiotherapy areas has recently been highlighted with the coronavirus disease 2019 pandemic that is currently extended worldwide. One of the main routes of contagion of severe acute respiratory syndrome coronavirus 2 occurs through the contact of the hands with contaminated surfaces and fomites, followed by the contact with the mucosa of the nose, mouth, and eyes.[31] Furthermore, it is known that the survival of severe acute respiratory syndrome coronavirus 2 on materials such as copper, cardboard, stainless steel, and plastic has been reported to be 4, 24, 48, and 72 hours, respectively, when it is maintained at 21 to 23°C and with 40% of relative humidity.[32] Disinfection is absolutely essential, not only of the physiotherapist's hands, but also of all instruments, equipment, and other fomites that will be in contact with the patient. Although these habits are widely described in community health hygiene practices, they are not always carried out in daily work and might have been a focus of transmission in the current pandemic.

Study limitations

It will be necessary to develop new studies aimed at determining the antibiotic susceptibility of the microorganisms found, as well as to develop preventive and regular monitoring strategies that control microbiological contamination with the aim of reducing the rate of nosocomial infections in the physiotherapist's work environment. Moreover, in the present study, only the contamination of aerobic bacterial microorganisms has been analyzed. It is necessary to extend the analysis to include anaerobic bacteria, fungi, and viruses as well, especially as the current coronavirus disease 2019 pandemic leads us to consider viruses as a potential threat in the health care work environment.

Conclusions

The microbiota of the physiotherapist's work environment is formed by a heterogeneous group of microorganisms, essentially commensals, coming from the environment, which are common on the surface of the skin and other processes of cross-contamination. What is significant is the presence of microbial contamination found on the everyday working instruments and equipment of the physiotherapist, especially the electrode sponges used in electrotherapy treatments, which seem to concentrate a wide variety of microorganisms, many of them responsible for the most common nosocomial infections. The microorganisms isolated most frequently in the physiotherapist's environment are opportunistic pathogens in immunosuppressed patients, those weakened by chronic diseases, elderly patients, or patients vulnerable owing to their immaturity. Therefore, it is necessary to establish corrective measures to evaluate and control these risks, as well as expanding this research with new studies focused on anaerobic bacteria, fungi, and viruses.

Suppliers

a. Copan Diagnostics.
b. Merck Millipore.
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References

1. Spanish Society of Preventive Medicine, Public Health and Hygiene. Study of Prevalence of Nosocomial Infections 2016 [Spanish]. Global Report of Spain 2016;27.
2. Craig CP. Infection control in the Physical Therapy Department. Infect Control Urol Care 1979;4:25-8.
3. McGuckin MB, Chung S, Humphrey N, Reisman P. Infection control practices in physical therapy. Am J Infect Control 1981;9:18-9.
4. Rimland D. Nosocomial infections with methicillin and tobramycin resistant Staphylococcus aureus–implication of physiotherapy in hospital-wide dissemination. Am J Med Sci 1985;290:91-7.
5. Pittet D, Dharan S, Touveneau S, Sauvan V, Perneger TV. Bacterial contamination of the hands of hospital staff during routine patient care. Arch Intern Med 1999;159:821-6.
6. Santus G, Brun C, Viani P, Pirali F, Pirali F. Nosocomial infections in the rehabilitation department. Eura Medicophys 2005;41:233-7.
7. Delgado Gil JA, Valenzuela Fernández AR, Prado Robles E, Fernández Díaz G. Hand hygiene of physiotherapists: prevention of nosocomial infections [Spanish]. Fisioterapia 2009;31:24-31.
8. Anguelov A, Giraud K, Akpabie A, Chatap G, Vincent JP. Predictive factors of acquired methicillin-resistant Staphylococcus aureus in a rehabilitation care unit [French]. Med Mal Infect 2010;40:677-82.
9. Kim LJ, Lee H, Kim H, Chang K. Isolation frequency and antimicrobial susceptibility of bacterial pathogens isolated from physical therapeutic instruments in general hospitals. J Phys Ther Sci 2010;22:61-7.
10. Cohen B, Larson EL, Stone PW, Neidell M, Glied SA. Factors associated with variation in estimates of the cost of resistant infections. Med Care 2010;48:767-75.
11. Lambert I, Tebbs SE, Hill D, Moss HA, Davies AJ, Elliott TS. Interferential therapy machines as possible vehicles for cross-infection. J Hosp Infect 2000;44:59-64.
12. Schabrun S, Chipchase L, Rickard H. Are therapeutic ultrasound units a potential vector for nosocomial infection? Physiother Res Int 2006;11:61-71.
13. Mobin M, de Moraes Borba C, de Moura Filho O, et al. The presence of fungi on contact electrical stimulation electrodes and ultrasound transducers in physiotherapy clinics. Physiotherapy 2011;97:273-7.
14. Spratt HG, Levine D, Tillman L. Physical therapy clinic therapeutic ultrasound equipment as a source for bacterial contamination. Physiother Theory Pract 2014;30:507-11.
15. Kim M, Kim LJ, Jo H, et al. High isolation frequency of *Acinetobacter baumannii* from physical therapy departments of geriatric care hospitals and antibiotic resistance patterns of isolated pathogens. J Phys Ther Sci 2012;24:105-9.
16. Evans MW Jr, Campbell A, Husbands C, Breshears J, Ndetan H, Rupert R. Cloth-covered chiropractic treatment tables as a source of allergens and pathogenic microbes. J Chiropr Med 2008;7:34-8.
17. Burnham K, Peterson D, Vavrek D, Haas M. The impact of microbial surveys on disinfection protocols in a chiropractic college environment. J Manipulative Physiol Ther 2009;32:463-8.
18. Brooks GF, Carroll KC, Butel JS, Morse SA, Mietzner TA. Chapter 10: Normal microflora of the human body. In: Jawetz M, editor. *Medical microbiology* [Spanish]. 25th ed. New York: McGraw-Hill-Lange; 2011. p 159-64.
19. Rippon F. Medical mycology [Spanish]. 4th ed. Barcelona: McGraw-Hill; 1997.
20. Rodríguez Martín JM. Low and medium frequency electrotherapy [Spanish]. Madrid: Mandala DL; 1994.
21. Maya J, Albornoz M. Transcutaneous and neuromuscular electrical stimulation [Spanish]. Barcelona: Elsevier; 2010.
22. Boye CS, Sow AI. Nosocomial infections: main causative agents. Dakar Med 2007;52:77-81.
23. Prevalence of nosocomial infections in Catalonia. II. Microorganisms and antimicrobial agents. Med Clin (Barc) 1990;95:161-8.
24. Berthelot P, Grattard F, Mallaval FO, Ros A, Lucht F, Pozzetto B. Epidemiology of nosocomial infections due to Pseudomonas aeruginosa, Burkholderia cepacia and Stenotrophomonas maltophilia. Pathol Biol (Paris) 2005;53:341-8.
25. Patterson JE. New Gram-positive agents in nosocomial infection. Curr Opin Infect Dis 2000;13:593-8.
26. Bergogne-Berezin E. Nosocomial infections: new agents, incidence, prevention. Presse Med 1995;24:89-97.
27. Jones RN. Resistance patterns among nosocomial pathogens: trends over the past few years. Chest 2001;119(2 Suppl):397S-404S.
28. Boucher HW, Corey GR. Epidemiology of methicillin-resistant Staphylococcus aureus. Clin Infect Dis 2008;46(Suppl 5):S344-9.
29. Menashe G, Borer A, Yagupsky P, et al. Clinical significance and impact on mortality of extended-spectrum beta lactamase-producing Enterobacteriaceae isolates in nosocomial bacteremia. Scand J Infect Dis 2001;33:188-93.
30. De Angelis G, Restuccia G, Venturiello S, et al. Nosocomial acquisition of methicillin-resistant Staphyloccocus aureus (MRSA) and extended-spectrum beta-lactamase (ESBL) Enterobacteriaceae in hospitalised patients: a prospective multicenter study. BMC Infect Dis 2012;12:74.
31. Hung LS. The SARS epidemic in Hong Kong: what lessons have we learned? J R Soc Med 2003;96:374-8.
32. van Doremalen N, Bushmaker T, Morris DH, et al. Aerosol and surface stability of SARS-CoV-2 as compared with SARS-CoV-1. N Engl J Med 2020;382:1564-7.