

Brief Communication

Nasal *Staphylococcus aureus* and methicillin-resistant *Staphylococcus aureus* carriage among college student athletes in northern Taiwan



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Abstract Of 259 college students in northern Taiwan surveyed, nasal carriage rate of *Staphylococcus aureus* and methicillin-resistant *S. aureus* (MRSA) was 22.4% and 1.54%, respectively and no significant difference was found between athlete students and non-athlete students. Three of four MRSA isolates belonged to sequence type 59, the endemic community clone. Copyright © 2017, Taiwan Society of Microbiology. Published by Elsevier Taiwan LLC. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

Introduction

Staphylococcus aureus, including methicillin-resistant (MRSA), is an important pathogen of serious infections in

humans.¹ Not only a hospital pathogen, MRSA is also a pathogen circulated in the community since 1990s.^{1,2} MRSA can colonize on anywhere of human bodies, particularly in the anterior nares.³ The carriage of *S. aureus*, including MRSA, is a significant risk factor for subsequent infection.^{1–3} Community-associated (CA)-MRSA isolates, initially identified in pediatric populations,^{1,2} were also reported in certain adult population which included competitive sports participants,^{1,2} especially the sports with frequent body contacts. There have been scanty reports on nasal MRSA carriage among competitive sports

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participants,^{4–8} and none from Taiwan. Therefore, we conducted this study to elucidate the carriage rate of *S. aureus*, including MRSA, among competitive sports participants in Taiwan.

Methods

This study was approved by Institutional Reviewing Board of Chang Gung Memorial Hospital (reference No: 102-1946B) and a written informed consent was obtained from each participant. Between June and September, 2013, 121 students from Chang Gung University (CGU) (non-athletes group) and 139 students of the department of sport training science from National Taiwan Sports University (NTSU) (athletes group), respectively, were recruited. Athlete students were further categorized into two groups by with or without close body contact. The contact sport group included basketball, Judokas, Taekwondo, and soccer. The non-contact group included tennis and table tennis. Eligible subjects were invited to participate, and specimens were obtained from their anterior nares for the detection of *S. aureus*. A questionnaire was completed for each subject, including demographics and potential risk factors for the acquisition of *S. aureus* and MRSA. Subjects whose roommates, close friends, or team mates were smokers were categorized as frequent smoking exposure.

A nasal swab specimen was collected from the anterior nares for each subject by a dry Copan Transystem Liquid Stuart swab (Venturi Transystem, Copan Innovation Ltd, Limerick, Ireland). Each nasal swab was circled in the participant's both nasal vestibules. The swabs were placed into the transport media and transported to the laboratory within 4 h. *S. aureus* as well as MRSA was identified and the antimicrobial susceptibility to 10 antibiotics was determined by using the disk-diffusion method, according to the recommendations of CLSI.

For molecular characterization, all *S. aureus* isolates were characterized by pulsed-field gel electrophoresis (PFGE), staphylococcal cassette chromosome (*SCCmec*) typing (only for MRSA), and detection of Panton–Valentine leukocidin (PVL) genes. Some isolates of representative pulsotypes were further typed by multilocus sequence type (MLST) and *spa* gene typing. All the molecular methods as well as *SCCmec* typing for type V_T were described elsewhere.⁹

Results

A total of 259 students, including 139 athlete students and 120 non-athlete students, were recruited. Age ranged from 18 to 35 years, with a mean of 20.6 years. In the athletes group, the mean age was 19.7 years and in the non-athletes group, 21.5 years. The male to female ratio was 1:0.43. Of the athletes group, 73% participated in contact sports and 27% non-contact sports.

Overall, *S. aureus* was identified in 58 students (22%), including MSSA in 54 students (21%) and MRSA in 4 students (1.5%). The mean ages of carriers of *S. aureus* and MRSA were 20.8 ± 2.89 years and 19.0 ± 1.16 years, respectively. No significant difference was found between the two groups (athletes vs. non-athletes) in terms of nasal carriage of

MSSA (21% vs. 21%) and MRSA (0.72% vs. 2.50%). Among the athlete students, *S. aureus* carriage rate varied from 10% for the Taekwondo category to 40% for the soccer category (Table 1).

Since only four students had MRSA colonization, it could not be calculated in an effective method to identify the risk factors. We analyzed the risk factor of carrying *S. aureus* and MSSA. The comparison of potential risk factors for the carriage of *S. aureus* between carriers and non-carriers is shown in Supplementary Table. Household members working as health care workers (HCWs) was a risk factor of carrying *S. aureus* ($p = 0.033$). Smoking or frequent smoking contact was a marginal protective factor ($p = 0.065$). The carriage rate for non-contact sports group was higher than that for contact sports group (32% vs. 18%, $p = 0.061$). There was no statistically significant difference between the carriers and non-carriers of *S. aureus* in terms of age, gender, prior hospitalization, using artificial catheters/tubes.

Fig. 1 reveals the detailed molecular characteristics of the four MRSA isolates. Three PFGE patterns were identified. All four isolates carried *SCCmec* IV or V_T. None of the isolates carried PVL genes. Three isolates from non-athletes belonged to sequence type (ST) 59/*spa* t437, the endemic CA-MRSA strains in Taiwan.

Of 54 MSSA isolates, a total of 18 pulsotypes were identified, nine pulsotypes identified in non-athlete students (unidentified pattern for one isolate), and 16 pulsotypes in athlete students (Table 1). Pulsotype BA, accounting for 15 (28%) of the MSSA isolates, was the dominant type and prevailed in both universities. The 15 isolates of pulsotype BA belonged to at least three STs, namely ST 6, 7 and 97, and at least six *spa* types. None of the isolates carried PVL genes. All 54 MSSA isolates were susceptible to vancomycin, teicoplanin, linezolid, trimethoprim-sulfamethoxazole and ciprofloxacin. Five of eight isolates which were resistant to erythromycin were also resistant to clindamycin. 39 isolates (72%) were resistant to penicillin. No statistically significant difference was found between the isolates from athletes and non-athletes in terms of antibiotic resistance rates.

Discussion

Results from the present study indicated that 1.54% of college students in northern Taiwan, 2.50% for non-athletes group and 0.72% for athletes group, harbored MRSA in their nares, and there was no statistically significant difference in carriage rate of MRSA between the two groups. The carriage rate of MRSA among the two universities' students was lower than that for general population (3.8%)^{1,2} and healthcare workers (5.0–7.8%)^{1,2} in northern Taiwan but was consistent with that for medical students (2.2%).²

Reviewing MRSA colonization among competitive sport participants published in the English language literature,^{4–8} we found that the carriage rate ranged from 0% to 37%. In the report from Ohio, USA, none of the recruited competitive sport participants harbored MRSA.^{4,7} Another report from Tennessee, USA,⁵ showed MRSA carriage rate varied significantly through the athletic season, from 4% to 23%, with a peak during the time of highest athletic activity. We

Table 1 Resolution and distribution of pulsotypes of methicillin-sensitive *Staphylococcus aureus* isolates from 54 students in two universities in Taiwan, 2013.

Category	No. of subjects	MSSA carriage No. (%)	No. (% in each category) of isolates							
			Type BA	Type AX	Type AK	Type BW	Type F	Type AY	Type B	Others ^c
Non-athletes	120	25 (21)	7 (28)	4 (16)	1 (4)	3 (12)	2 (8)	3 (12)	2 (8)	3 (12)
Athletes	139	29 (21)	8 (28)	2 (6.9)	5 (17)	1 (3.4)	2 (6.9)	0	1 (3.4)	10 (34)
Contact sports	102	17 (17)	5 (29)	2 (12)	2 (12)	1 (5.9)	1 (5.9)	0	0	6 (35)
Soccer	15	6 (40)	2 (33)	1 (17)	0	0	1 (17)	0	0	2 (33)
Basketball	20	3 (15)	1 (33)	1 (33)	0	1 (33)	0	0	0	0
Taekwondo	30	2 (6.7)	2 (100)	0	0	0	0	0	0	0
Judokas	37	6 (16)	0	0	2 (33)	0	0	0	0	4 (67)
Non-contact	37	12 (32)	3 (25)	0	3 (25)	0	1 (8.3)	0	1 (8.3)	4 (33)
Tennis	16	4 (25)	0	0	1 (25)	0	0	0	1 (25)	2 (50)
Table tennis	21	8 (38)	3 (38)	0	2 (25)	0	1 (13)	0	0	2 (25)
Total	259	54 (21)	15 (28)	6 (11)	6 (11)	4 (7.4)	4 (7.4)	3 (5.6)	3 (5.6)	13 ^c (24)
Molecular characteristics										
Sequence type			6, 7, 97	188	508, 2845	UT	15, 2846 ^a	12	623	12, 59 ^b
Spa type			t91, t267, t289, t701, t9476, t13479	t189	t630, t026	UT	t547, t13478	t213	t2182, UT	t3418, t437 ^b

UT, untypeable.

^a ST 2846 is a single locus variant of ST 5.

^b Characteristics for one isolate of pulsotype C.

^c Pulsotypes of 10 isolates were singletons. One isolate could not be typed by pulsed-field gel electrophoresis.

recruited the competitive sports participants after or during their training season; however, only one MRSA carrier was identified. Lately, Champion et al.⁸ obtained swabs for culture of MRSA from nasal, axillary, and inguinal sites of 201 student athletes each week for 12 weeks and 74 (37%) of them were positive for MRSA during the study period. Nearly half of MRSA-positive participants carried MRSA in axillary or inguinal sites, but not in the anterior nares, suggesting that a higher positive rate may be detected if more samplings from multiple sites are taken.

In the present study, nasal *S. aureus* carriage among athlete students was 21.3%, which was consistent with that (23.2%) in a report from Ohio, USA.⁴ Although frequent body contact might be an important pathway for transmission of *S. aureus*, nasal *S. aureus* carriage rate for athletes among contact sport group was borderline significantly lower than

that for non-contact sport group in the present study. Both environment exposure and personal hygiene may also be highly related. In addition, household members working as HCWs was a borderline risk factor for harboring MRSA ($p = 0.065$) but a significant risk factor for harboring *S. aureus* ($p = 0.033$). In contrast, older age, male gender and prior antibiotic usage previously reported¹⁰ as risk factors for *S. aureus* carriage were not demonstrated in the present study. The results might also be affected by the subjects recruited and the country conducted.

In the current study, all four MRSA isolates carried either type IV or V SCC, suggesting community origin, and three of them belonged to ST59/spa t437, which is the most common community clone of MRSA prevailing in Taiwan.^{1,2,11} We also found that nearly 30% of MSSA isolates shared a common PFGE type, namely type BA (belonged to ST 6, 7,

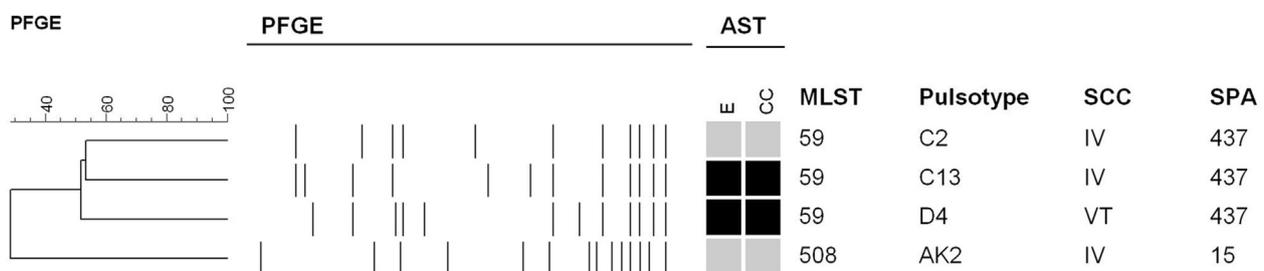


Figure 1. Molecular characteristics of methicillin-resistant *Staphylococcus aureus* isolates from four college students. All four isolates were resistant to penicillin, and susceptible to vancomycin, teicoplanin, linezolid, ciprofloxacin, doxycycline, trimethoprim-sulfamethoxazole and fusidic acid. Antimicrobial susceptibility tests (AST): black indicates resistance, and gray indicates susceptibility. Abbreviations are as follows: erythromycin (E), clindamycin (CC). PFGE, pulsed-field gel electrophoresis. PVL, Pantón–Valentine leucocidin genes. SCC_{mec}, staphylococcal cassette chromosome *mec*; MLST, multilocus sequence typing.

and 97), a strain prevailing in both universities. This strain of PFGE type BA was also the predominant strain in a cluster of MSSA colonization in the nursery of Chang Gung Memorial hospital at Linkou⁹ and in a survey of *S. aureus* colonization among neonatal intensive care units in Taiwan.⁹ The clinical significance and impact of this MSSA strain in Taiwan need further studies.

There are several limitations for the present study. First, only 139 athlete students and 121 non-athlete students, lower than expected, participated in this study, which reduced the size of case number for evaluation and indirectly affected the analysis of statistical significance. Second, from each subject, samplings for MRSA detection were obtained only from one site (nares) and once, so some MRSA colonizing subjects might be undetected and the longitudinal trends could not be traced.

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The authors have no financial relationships relevant to this article to disclose.

Conflicts of interest

The authors have no conflicts of interest relevant to this article to disclose.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at <http://dx.doi.org/10.1016/j.jmii.2016.11.005>.