Primary Tooth Wear in Functional Lateralities

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ABSTRACT

Purpose: The purpose of this study was to explore the sidedness of primary tooth horizontal wear facets between the left and right sides of the dentition among 2 types of functionally lateralized (hand, foot, eye) children—those who were true right-sided (**TRS**), and partially or totally nonright-sided (**NRS**) at 4 years of age.
Methods: Study subjects were 855 children with signs of wear in deciduous teeth on the dental casts (N=1,720) of the GOS (Genetic Odontometric Study of the Collaborative Perinatal) project, carried out in the 1960s in the United States by the National Institute of Neurological Disorders and Stroke (NINDS) in a cross-sectional manner at a mean age of 8½ years (40% Caucasian and 60% African-American children). The statistical method used was chi-square analysis.
Results: Tooth wear was identified from dental casts in approximately 50% of cases. Wear was symmetric (equal on the right and left) in 49% of these dentitions, while asymmetric wear was found in 50%. Left-sided extra wear was slightly more common (26%) than right-sided extra wear (24%), but gender and race differences appeared. Statistically significant unilateral wear was found among TRS Caucasian boys on the dentition's right side. In NRS Caucasian boys, however, the left-sided extra wear was more common than for the right-sided extra wear (P=.04). In Caucasian girls, the same relationship appeared, but the difference was not significant (P=.11). In African American TRS children, the left-sided extra wear was more common, and symmetric proportion was increased in boys. The differences between laterality and gender groups, however, were not statistically significant.
Conclusions: Sidedness in the form and function of a primary dental apparatus has variation among gender and race groups that is involved with the determination of general structural and functional lateralities. Early asymmetric oral functioning (unilateral bolus placement, sucking, chewing, bruxism, etc) should be considered in registration of the various phases of occlusal development, also having craniofacial aspects due to asymmetric growth promoting function.
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Tooth-to-tooth occlusal contact occurs in mastication and many other oral functions, causing attrition of teeth in both primary and secondary dentitions. Tooth wear facets are common, occurring in approximately 50% of children.[1] In general, bilaterally balanced symmetric wear is beneficial in view of growth-promoting function of the developing occlusion in primary and mixed dentitions. Posterior tooth wear has been reduced in western style living children due to soft food associated with an increased number of malocclusions and the need for orthodontic treatment.[2] Juvenile bruxism is one of the most common aetiological factors in primary tooth horizontal wear, and horizontal facets are typical of bruxism. Generally, primary tooth wear facets are due to a parafunctional or functional habit, influenced by inborn and environmental factors.[3-5]

The temporomandibular joint is a diarthrodial structure, and the movement of the jaw produced by muscular function is bilateral with a tendency of symmetric tooth wear. Worn crown peaks suggests that some teeth in the dental row are under the influence of heavier shearing forces when compared to other teeth, which are less worn or even unworn (ie, when masticatory function is unbalanced between the dentition's right and left sides).

Malocclusions are often related to bruxism, but only a few significant relationships have been found between tooth wear and occlusal traits.[6] The causal relationships remain obscure between various malocclusions and unbalanced function, and aetiologically there is not a direct correlation.[8] Early right/left unbalanced occlusal function has been held as a component of the functional matrix that slowly produces asymmetric growth of skull bones in animal studies.[7]

Human laterality is a long, developmental process which has not been applied frequently in traditional dental asymmetry research.[9-12] Functional laterality is obviously based on the anatomic laterality of the human body and the brain (such as the center of speech in the Broca's area on the brain's left side) associated with the cognitive development, handedness, footedness, eyedness etc. This produces different numbers of left- and right-handed and left- and right-footed individuals, the proportions for whom are quite equal (ie, it is genetically determined in various populations). For mature occlusal function, there doesn't appear to be any specific laterality[13] or focal center in the brain. It has been hypothesised that some regions of the brain are activated in some forms of bruxism. This assumption has appeared in the thegotic literature,[14-17] as "sharpening" of teeth in some animals and also in man under the influence of stress. This topic has been illuminated recently by neurological studies based on modern methods studying rhythmic behaviour, tongue control, chewing sidedness, and simultaneous activities in the brain stem and contralateral cortex.[18-20]

Brain unilateral maturation has been explored by Thatcher et al,[21] suggesting that human cerebral hemispheres develop at different rates postnatally, which is chronologically comparable to stages in perceptual, cognitive development until 3 years of age. During that period, a great variation may exist between individuals. Annett[22-24] has proposed that, in 15% to 20% of the population, the common lateralizing influence (right shift [RS] factor) is weak or absent, perhaps due to a recessive genetic allele (RS-negative). Among this minority, different manifestations of laterality are dictated independently and at random. In general, there has been a strong current towards a genetic background in human laterality understanding, but environmental and intermediate perspectives also exist.[25,26]

Critical time for the factors causing laterality in body and head structures appear during embryonal disc formation from the second week of development,[27] and up to the third trimester of pregnancy. This produces the basis for the functional laterality and common right-sidedness in RS-positive individuals.[28,29] Normally, teeth and dentitions are symmetric in relation to the midline, showing only fluctuating asymmetry. In earlier studies, asymmetric sagittal and transversal occlusal relationships as well as permanent tooth eruption have shown variation in laterality development,[30-33] but the role of the sidedness of the masticatory function of the primary dentition is unknown.

Hypothetically, the timing of the general developmental right shift and the initial chewing preferences in primary dentition may coincide, producing temporary or permanent dominance unilaterally. Gisel et al[34] and Gisel[35] showed that normal children underwent a transition from predominantly placing food on the right side at 2 years of age to predominantly placing it on the left side at 4 years of age. This also was influenced by the texture of the food.[36,37]

In adults, no systematic difference has been found between the occlusion's left and right sides in mastication and the observed lateral preference could not be predicted from hand laterality.[13,38-40]

This study's purpose was to explore sidedness of tooth wear of the primary dentition among 2 types of functionally lateralized children—those who are true right-sided, and partially or totally nonright-sided.

METHODS

Study participants comprised 855 children with signs of wear facets on the occlusal surfaces of deciduous teeth. These children were chosen from 1,720 individuals included in the Genetic Odontometric Study (GOS) project, which sampled from approximately 60,000 pregnancies. The study comprised the Collaborative Perinatal Project of the National Institute of Neurological Disorders and Stroke (NINDS) carried out in the 1960s in the United States. The dental examinations (casts and photographs included) were performed at 6 of the collaborating medical centres (Buffalo, NY, Richmond, Va, Portland, Ore, Philadelphia, Pa, Providence, RI, and Johns Hopkins, Md) in the early 1970s in a cross-sectional manner. The mean ages at the time of dental examination were 7.9 years for Caucasian boys, 7.8 for Caucasian girls, 8.9 for African American boys, and 9.3 for African American girls. Forty percent were Caucasian and 60% were African American children ranging in age from 6.9 to 12.7 years in 95% of the cases.

At each cooperating institution, alginate impressions were taken and normal dental plaster casts made. Casts were checked and compared with oral photographs, taken from every child in the study. The teeth with heavy decay, restorations, an exfoliating phase, orthodontic appliances, and casts with missing antimeric teeth were not studied. Tooth wear examinations were done at the University of Oulu, Finland, Institute of Dentistry, by 1 observer with vi-

Figure 1. The 3 types of primary tooth wear.

sual inspection of casts evaluating the approximated sum of wear facet area. Each case was coded as "symmetric wear" if there was visible attrition in primary teeth, but no difference was noticed between the right and left side. "Asymmetric wear" was noted if there was a difference between the right and left sides (coded as right or left sider) with increased wear on that side (Figure 1). The test was repeated in 100 casts to determine the intraexaminer methodological error, resulting in a kappa value of 0.68 for the upper and 0.72 for the lower primary teeth. Only upper primary teeth were used for the statistical analyses, due to the more advanced exfoliation of the lower primary teeth in these age groups.

Eye, hand, and foot laterality examinations were recorded at 4 years of age at each center, according to uniform manual instructions used in the Collaborative Perinatal Project. Hand preference was evaluated by placing color pencils directly in front of the child, who was asked to make an "X" on a piece of paper with each pencil. If the same hand was not used with each of the 3 pencils, the test was repeated 2 more times. Any preference fewer than 4 out of 5 was coded as indeterminate. Eye preference was detected by asking the child to look through a kaleidoscope, with the experimenter noting which eye was used. Foot preference was detected by placing a ball in front of the child, and he/she was asked to kick it 3 times. Each trial was initiated from a stable initial standing position. The experimenter noted whether there was a consistent preference in 3 trials. If 2 right and 1 left (or vice versa) responses were obtained, 2 more trials were made. Any preference fewer than 4 out of 5 was coded as undetermined. Patterns of lateral preferences, inter-relationships, sex and race differences in functional literalities, and malocclusions were compared. Details on the Collaborative Perinatal Project children are presented and discussed elsewhere.[30-32,35,38]

Functional true right-sidedness was compared with nonright-sidedness using the combinations constructed from all 3 functional categories (Table 1). Children with a complete set of right-handedness, right-footedness, and right-eyedness (true right-sidedness "TRS") were compared with children with a variable amount of mixed or complete nonright-sidedness ("NRS"). Indeterminate cases also were calculated here within the NRS group. Statistical testing was performed by comparing the equality of the symmetric/asymmetric wear proportions (2x3, 2x2 tables and chi-square tests) for the upper primary teeth. This approach was performed separately in each laterality and in gender and race groups. *P*-values <.05 were considered significant.

Table 1. Functional laterality combinations measured at 4 years of age

EYE	**HAND**	**LEG-dominance**				
		right	**left**	**indeterminate**	**total**	
right	right	285	17	10	312	
right	left	8	9	1	18	
right	indet.	45	11	4	60	
left	right	183	12	14	209	
left	left	13	19	0	32	
left	indet.	47	12	2	61	
indet.	right	23	3	1	27	
indet.	leftt	2	3	0	5	
indet.	indet	4	2	2	8	
		610	88	34	732	Total
				123 (incomplete set of laterality determinations)	855	Grand total

*Table 2. The Distribution of Asymmetric Wear in True Right-sided (TRS) and Nonright-sided (NRS) Children by Gender and Race**

	TRS		NRS				
	Left sider	Right sider	Left sider	Right sider	N	Chi-square	P
CB *	13	25	30	23	91	4.5	.04
CG	12	19	24	18	73	2.4	.11
AAB	19	9	32	34	94	2.9	.09
AAG	25	15	35	33	108	1.2	.27

** CB, Caucasian boys. CG, Caucasian girls. AAB, African American boys. AAG, African American girls.*

RESULTS

Primary tooth wear facets were identified from dental casts in 855 upper primary dentitions, of which 732 had a complete set of functional laterality determination (Table 1) . Tooth wear was symmetric in 49% of these dentitions, while asymmetric wear was found in 50% (Figure 2). In general, left-sided extra wear was slightly more common (26%) than right-sided extra wear (24%). These proportions, however, differed among African American and Caucasian children (Table 2, Figure 7), and functional laterality groups (Figure 3).

When gender and race were considered as confounding factors, it was found that, in true right-sided Caucasian boys, right-sided extra wear was more common than left-sided extra wear. Furthermore, in nonright-sided Caucasian boys, left-sided extra wear was more common than right-sided extra wear (P=.04; Table 2). In Caucasian girls, the same relationship appeared, but the difference was not statistically significant (P=.11).

In African American children, an opposite relationship was seen. Left-sided extra wear was more common in true right-sided African American children (P=.09 in African American boys, P=.27 in African American girls). The numbers of left and right extra wearers were almost equal in nonright-sidedness, and true right-sided African American boys had the greatest amount of symmetric primary tooth wear (Figure 7). The differences, however, were not statistically significant in African American children (Table 2).

When symmetric/asymmetric proportions were explored among each laterality separately, the right-handed (Figure 4) and right-footed (Figure 5) children tended to have more symmetric wear compared to their nonright-sided counterparts. Respectively, asymmetric tooth wear was more common among nonright-sided individuals (Figures 3-6).

DISCUSSION

Uni- and bilateral distributions of wear facets of primary dentition in 2 types of children, TRS and NRS, suggest that masticatory function is under the influence of lateralizing factors in the first years of life. These factors are genetically determined and they seem to interfere with the timing of other developmental processes, which is typical for each sex and race group. The results indicate that the timing of RS-factor (shift of functions to the right side) differentially influence African American children when compared to Caucasians. The latter group is more right-shifted in tooth wear. This is also the case between boys and girls, with boys being more right-shifted and lateralized. Differences in RS expressivity have been postulated between the sexes and between twins and the single-born.

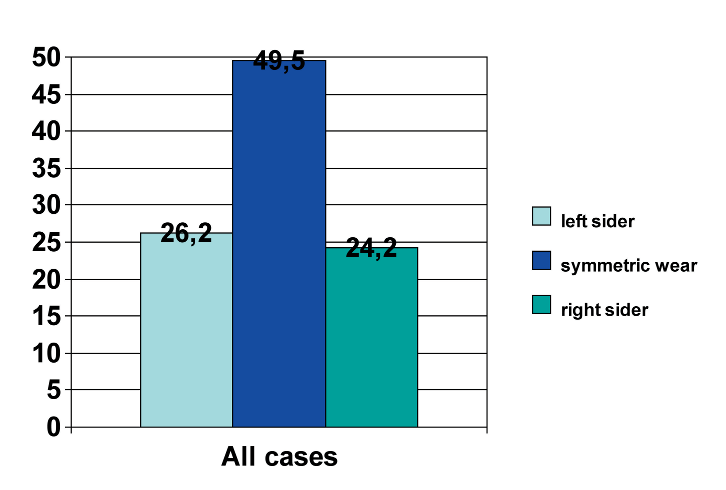

Figure 2. Percentages of symmetric and asymmetric wear in the primary dentitions (all cases).

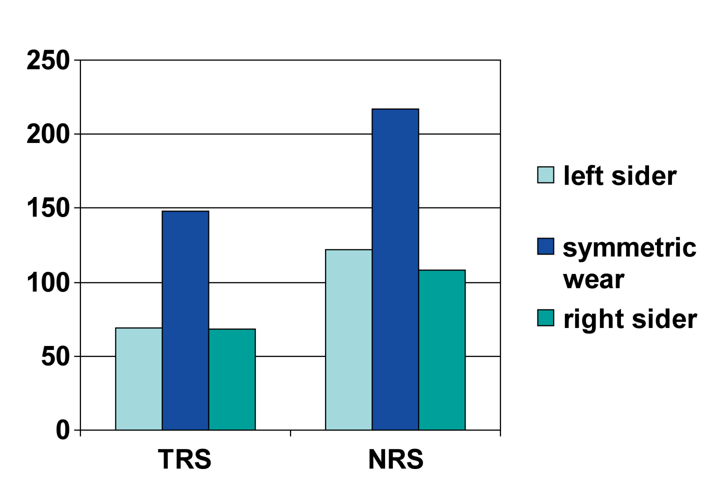

Figure 3. No. of cases of symmetric and asymmetric primary tooth wear in combined lateralities (hand, foot, and eye). TRS=true right-sidedness; NRS=nonright-sidedeness.

These have been tentatively attributed to differences in relative growth and/or maturity at birth or soon afterwards.[28]

The sexual and racial proportional differences in primary tooth wear laterality are probably due to the differential timing of dental maturity and other factors that influence the initial function of the occlusion. In general, the racial differences are present in mineralization. In the rate of eruption of permanent teeth, these are achieved by African Americans significantly earlier than Caucasians.[41] This is also the case between girls and boys, with girls being ahead of boys in both races. Boys, however, are more asymmetric in structure and more laterally determined, which has been suggested to be an effect of fetal testosterone.[29]

Oral function is an effective factor in the occlusal development of the 2 dentitions.[42] Some of the unilateral structural arrangements in the early occlusal relationships may be involved in right/left unbalanced masticatory function. Unilaterally increased mastication (bolus placement, chewing, bruxism) produces a complex functional matrix and is not frequently studied. It is, however, apparently one of the molding factors of the skull and face.[7,43] It is difficult to ascertain in a growing subject, however, if the unbalanced oral function causes asymmetric structure or vice versa and how and when in the course of growth these are inter-related. It also would be interesting to study conditions—such as a finger-sucking habit, whether it is a lateralized (or "contralateralized") hand function—causing uni- or bilateral malocclusions.

Crossbite studies indicate that TRS children had significantly more normal occlusion than NRS children and significantly less right-sided crossbite.[33] The same relationship appeared in unilateral angle Class II studies, where 85% of the TRS had bilaterally symmetric occlusion (AI or AII), while in NRS that proportion was 80%.[32] When the NRS children were placed into categories according to their degree of nonright-sidedness (RRL, RLL, LLL, etc), a moderate nonright-sidedness (RLL) was associated with a significantly increased proportion of right-sided unilateral AII.

It is interesting that functional true right-sidedness and right-sided tooth wear are significantly associated (Table 2). From anthropometric studies, a fact appears that true right-sidedness and skull asymmetry are associated (a larger left side of the skull with displacement of temporal fossa), while nonright-sidedness is associated with symmetry.[44] This suggests that basic asymmetric structure of the head[45], causing asymmetry of the face in newborns, is compensated later with unilateral growth (right-sided masticatory function) probably determined and arranged by genetic factors (ie, during the primary dentition's early function, there is a right shift period). Unilateral malocclusions appear frequently with asymmetric skull, and the aetiologies for such types of malocclusion should be explored, also including the variability of early sidedness of oral functions, in addition to decreased function.

Structural laterality is quite seldom seen in the teeth, mandible, maxilla, and head bones, but anthropometric studies have shown that the mandible's left side is larger than the right side.[46] It was also found that the left sides of the occipital, malar, and sphenoid bones are larger compared to the right sides. On the other hand, the frontal, temporal, and parietal bones show an opposite difference. The internal length of the skull is larger on the right side than on the left. In the brain, the left temporal plane is larger than the right prenatally, and a long frontal lobe is more common on the right than on the left.[9,47] The complex associations between anatomical and functional asymmetries contribute to individual differences in cerebral organization.[48] Some of these asymmetries are significant in right-handed individuals and less marked in functionally nonright-sided

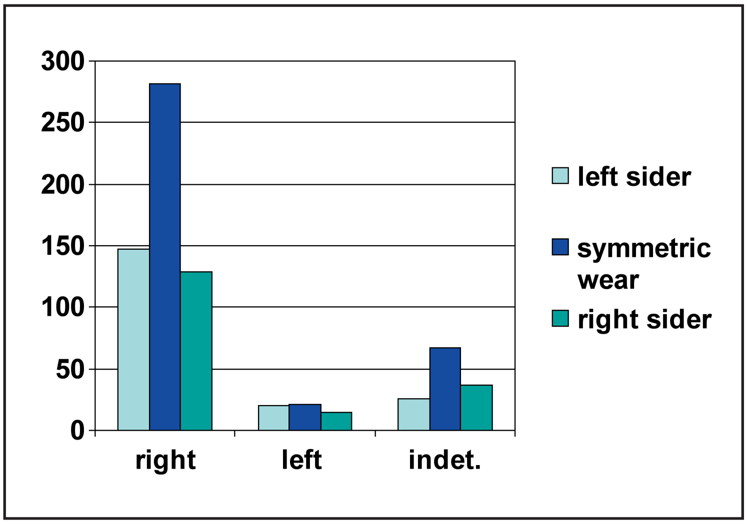

Figure 4. No. of cases with symmetric and asymmetric wear of primary teeth in handedness (N=744).

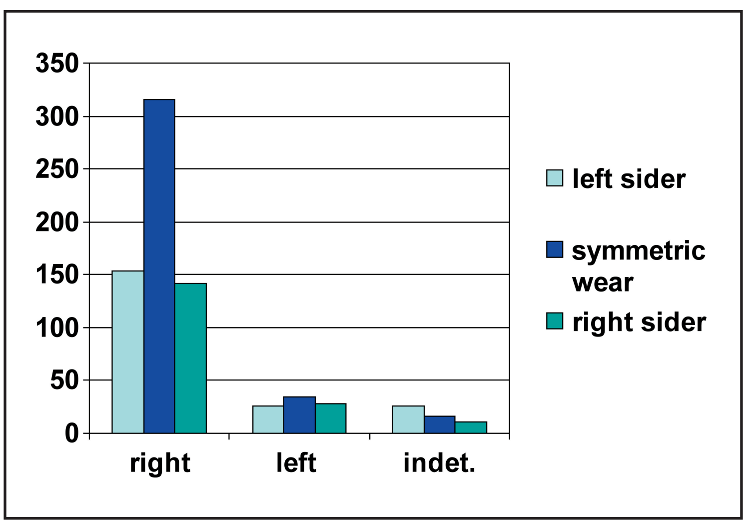

Figure 5. No. of cases with symmetric and asymmetric wear of primary teeth in footedness (N=734).

individuals.[49] Function has a considerable role in bone formation and growth—apparently the sutures between the bones in the skull are important intermediators. Asymmetry of the glenoid fossa position relative to the skull base structures has been reported in adult skull material in man, with the right-side structures being more laterally and distally positioned than the left-side ones.[50]

It is interesting to speculate that masticatory lateralized function may have either a:

1. balancing effect on the readily asymmetric skull if the functional side is adequate; or
2. diverse asymmetric growth effect if the dominating functional side is inadequate.

The proportions of asymmetric malocclusions and the distribution of primary tooth wear facets in TRS and NRS children should encourage investigations to explore such relationships. It is a difficult challenge to those involved in preventive orthodontic and orthopedic therapy to recognize those children who need guidance for asymmetric growth and/or unbalanced function. Before clinical recommendations, however, more research should be done to determine an adequate functional treatment in the primary dentition. A good start could be to uncover asymmetric oral functions when various occlusal developmental phases are inspected and registered.

The pattern of sidedness of oral functions as it relates to the early developing occlusion is characteristic for an individual.[51] During early development, it is synthesized by the central nervous system,[52] the functions of which are under the influence of lateralizing factors in the first years of life. This concept has not been thoroughly studied, and it remains open for further study.

CONCLUSIONS

The sidedness of the primary dentition tooth wear varies with different types of functional lateralities. In the present study, wear appears in approximately 50% of the children investigated in the early 1970s between 6 to 12 years of age. Circa fifty percent of the worn dentitions express symmetric wear (equal for left and right sides), and 50% express asymmetric wear (ie, more tooth wear on the left side among African American children and on the right side among Caucasian children). This pattern seems to have variation in the functional lateralities and the child's gender. Right-sided tooth wear appears in true right-sided Caucasian boys significantly more often than left-sided tooth wear, while nonright-sided children in general have equal amounts of lateralized tooth wear on both sides of the dentition. The proportion of symmetric tooth wear and increased left side wear was greater among true right-sided African American children. These differences in tooth wear patterns may be a consequence of structural and functional sidedness during primary dentition occlusal development (ie, in 1- to 3-year-old children), which has simultaneous developmental lateralization processes that vary according to genetic background, including right shift factor.

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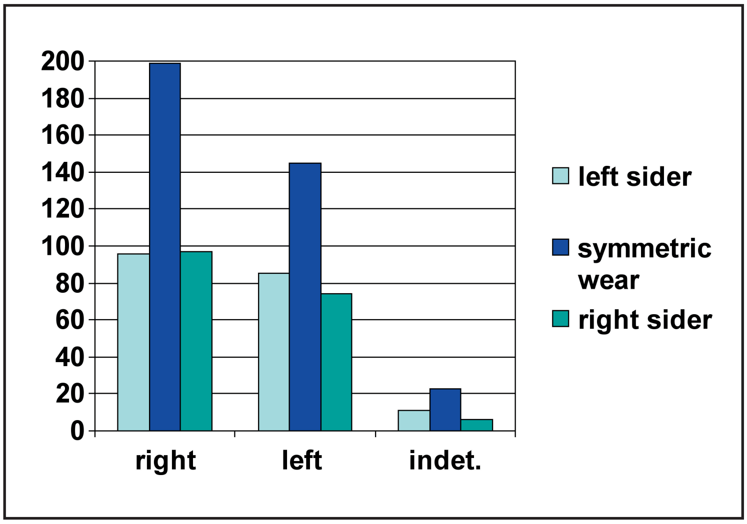

Figure 6. No. of cases with symmetric and asymmetric wear of primary teeth in eyedness (N=736).

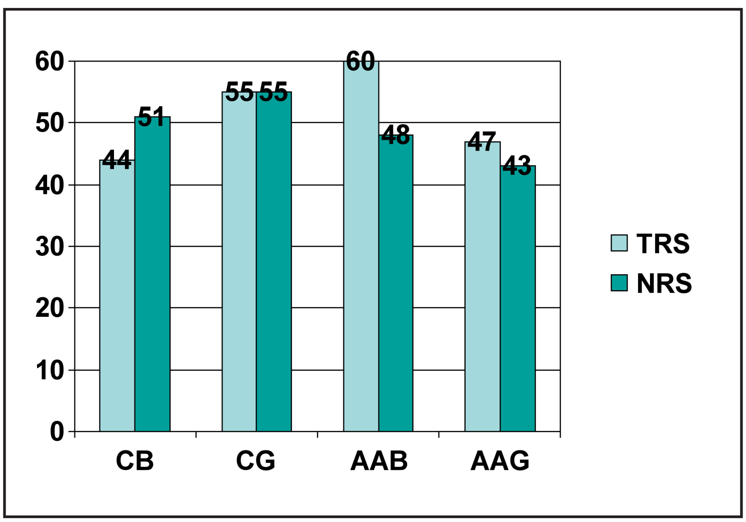

Figure 7. Percentages of symmetric wear among true right-sided (TRS) and nonright-sided (NRS) children by gender and race. CB=Caucasian boys; CG=Caucasian girls; AAB=African American boys; AAG=African American girls.

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